BIOLOGICAL BULLETIN

OF THE

Woods Hole, Mass.

Marine Biological Laboratory

WOODS HOLE, MASS.

Editorial Staff

E. G. CONKLIN—*Princeton University.*

GEORGE T. MOORE—*The Missouri Botanic Garden.*

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W. M. WHEELER—*Harvard University.*

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Managing Editor

FRANK R. LILLIE—*The University of Chicago.*

VOLUME XLIX.

WOODS HOLE, MASS.

JULY TO DECEMBER, 1925

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Editorial Staff

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FRANK R. LILLIE—*The University of Chicago.*

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BIOLOGICAL BULLETIN

THE MARINE BIOLOGICAL LABORATORY.

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I. TRUSTEES

(AS OF AUGUST 12, 1924).

EX OFFICIO

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GILMAN A. DREW, *Assistant Director*, Marine Biological Laboratory.
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GILMAN A. DREW, *Ex. off.*
IVEY F. LEWIS, to serve until 1927.
E. G. CONKLIN, to serve until 1926.
W. E. GARREY, to serve until 1925.

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J. R. SCHRAMM, Cornell University.
E. E. JUST, Howard University.
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II. ACT OF INCORPORATION.

No. 3170

COMMONWEALTH OF MASSACHUSETTS.

Be It Known, That whereas Alpheus Hyatt, William Sanford Stevens, William T. Sedgwick, Edward G. Gardiner, Susan Minns, Charles Sedgwick Minot, Samuel Wells, William G. Farlow, Anna D. Phillips and B. H. Van Vleck have associated themselves with the intention of forming a Corporation under the name of the Marine Biological Laboratory, for the purpose of establishing and maintaining a laboratory or station for scientific study and investigation, and a school for instruction in biology and natural history, and have complied with the provisions of the statutes of this Commonwealth in such case made and provided, as appears from the certificate of the President, Treasurer, and Trustees of said Corporation, duly approved by the Commissioner of Corporations, and recorded in this office;

Now, therefore, I, HENRY B. PIERCE, Secretary of the Commonwealth of Massachusetts, *do hereby certify* that said A. Hyatt, W. S. Stevens, W. T. Sedgwick, E. G. Gardiner, S. Minns, C. S. Minot, S. Wells, W. G. Farlow, A. D. Phillips, and B. H. Van Vleck, their associates and successors, are legally organized and established as, and are hereby made, an existing Corporation, under the name of the MARINE BIOLOGICAL LABORATORY, with the powers, rights, and privileges, and subject to the limitations, duties, and restrictions, which by law appertain thereto.

Witness my official signature hereunto subscribed, and the seal of the Commonwealth of Massachusetts hereunto affixed, this twentieth day of March, in the year of our Lord One Thousand, Eight Hundred and Eighty-Eight.

[SEAL]

HENRY B. PIERCE,
Secretary of the Commonwealth.

III. BY-LAWS OF THE CORPORATION OF THE MARINE BIOLOGICAL LABORATORY.

I. The annual meeting of the members shall be held on the second Tuesday in August, at the Laboratory, in Woods Hole, Mass., at 12 o'clock noon, in each year, and at such meeting the members shall choose by ballot a Treasurer and a Clerk, who shall be, *ex officio*, members of the Board of Trustees, and Trustees as hereinafter provided. At the annual meeting to be held in 1897, not more than twenty-four Trustees shall be chosen, who shall be divided into four classes, to serve one, two, three, and four years, respectively, and thereafter not more than eight Trustees shall be chosen annually for the term of four years. These officers shall hold their respective offices until others are chosen and qualified in their stead. The Director and Assistant Director, who shall be chosen by the Trustees, shall also be Trustees, *ex officio*.

II. Special meetings of the members may be called by the Trustees to be held in Boston or in Woods Hole at such time and place as may be designated.

III. The Clerk shall give notice of meetings of the members by publication in some daily newspaper published in Boston at least fifteen days before such meeting, and in case of a special meeting the notice shall state the purpose for which it is called.

IV. Twenty-five members shall constitute a quorum at any meeting.

V. The Trustees shall have the control and management of the affairs of the Corporation; they shall present a report of its condition at every annual meeting; they shall elect one of their number President and may choose such other officers and agents as they may think best; they may fix the compensation and define the duties of all the officers and agents; and may remove them, or any of them, except those chosen by the members, at any time; they may fill vacancies occurring in any manner in their own number or in any of the offices. They shall from time to time elect members to the Corporation upon such terms and conditions as they may think best.

VI. Meetings of the Trustees shall be called by the President, or by any two Trustees, and the Secretary shall give notice thereof by written or printed notice sent to each Trustee by mail, postpaid. Seven Trustees shall constitute a quorum for the transaction of business. The Board of Trustees shall have power to choose an Executive Committee from their own number, and to delegate to such Committee such of their own powers as they may deem expedient.

VII. The President shall annually appoint two Trustees, who shall constitute a committee of finance, to examine from time to time the books and accounts of the Treasurer, and to audit his accounts at the close of the year. No investments of the funds of the Corporation shall be made by the Treasurer except approved by the finance committee in writing.

VIII. The consent of every Trustee shall be necessary to dissolution of the Marine Biological Laboratory. In case of dissolution, the property shall be given to the Boston Society of Natural History, or some similar public institution, on such terms as may then be agreed upon.

IX. These By-laws may be altered at any meeting of the Trustees, provided that the notice of such meeting shall state that an alteration of the By-laws will be acted upon.

X. Any member in good standing may vote at any meeting, either in person or by proxy duly executed.

IV. THE REPORT OF THE TREASURER.[1]

HARVEY S. CHASE & COMPANY
Certified Public Accountants
84 State Street, Boston.

February 9, 1925.

MR. LAWRASON RIGGS, JR.,
25 Broad Street,
New York.

Dear Sir: We have audited the accounts of the Marine Biological Laboratory for the year ended December 31, 1924 and report thereon in the following exhibits and schedules, together with our comments, viz:

Exhibit A—Balance-Sheet, December 31, 1924.
Exhibit B—Income-and-Expense, Year ended December 31, 1924.
Schedule I—Securities held by Central Union Trust Company of New York as Trustees under Agreement dated January 22, 1924.
Schedule II—Lucretia Crocker Fund, December 31, 1924.

[1] Schedules IV and V are not included in this report. The complete audit is on file at the Laboratory, and may be examined by any member.

Schedule III—Cash Receipts and Payments, Reserve and Library Funds, January 8, 1924 to December 31, 1924.

Schedule IV—Land, Buildings, and Equipment, December 31, 1924.

Schedule V—Supply Department Income-and-Expense Account, Year ended December 31, 1924.

During the year 1924 the Laboratory received endowment fund gifts amounting to $905,000.00 and a building fund gift of $500,000.00.

The receipt of these large gifts made it advisable to change the arrangement of the balance-sheet and we have, therefore, set it up in the form that has been generally adopted by larger endowed institutions. We have also regrouped the items in the income-and-expense statement—Exhibit B.

We certify that the balance-sheet and income-and-expense statement shown in Exhibits A and B in our opinion set forth correctly the financial condition of the Marine Biological Laboratory at December 31, 1924, and the results of its operations for the year ended on that date.

Very respectfully,

HARVEY S. CHASE & COMPANY,

Certified Public Accountants.

EXHIBIT A

MARINE BIOLOGICAL LABORATORY BALANCE-SHEET, DECEMBER 31, 1924.

Assets.

Endowment Fund Assets:			
Securities in Hands of Trustee—Schedule I		$905,097.50	
Cash in Hands of Trustee		12.00	
		$905,109.50	
Lucretia Crocker Fund Assets,			
Securities—Schedule II	$ 4,005.17		
Cash—Schedule II	427.19	4,432.36	$ 909,541.86
Plant Assets:			
New Laboratory Building,			
Expenditures to December 31, 1924		$452,106.14	
Cash in Building Fund		56,615.53	
Total (See Contra)		$508,721.67	

Other Plant Assets—Schedule IV.			
Land	$102,094.89		
Buildings	236,126.82		
Equipment	108,837.49		
	$447,059.20		
Less Reserve for Depreciation	69,768.47	377,290.73	886,012.40
Current Assets:			
Cash,			
In New York Bank	$ 13,821.67		
In Hands of Trustee	2,200.00		
In Falmouth Bank	4,228.95		
Petty Cash	500.00	$ 20,750.62	
Accounts—Receivable		19,586.38	
Inventories,			
Supply Department	$ 24,558.41		
Biological Bulletin	3,483.21	28,041.62	
Investments,			
Gansett Property Account	$ 7,993.23		
Stock in General Biological Supply House, Inc.	12,700.00	20,693.23	
Prepaid Insurance		1,834.71	
Items in Suspense		1,313.32	92,219.88
			$1,887,774.14

Liabilities.

Endowment Funds:			
Friendship Fund, Inc.	$405,000.00		
John D. Rockefeller, Jr.	400,000.00		
Carnegie Corporation	100,000.00		
Gain on Sale of Securities during Year	109.50		
	$905,109.50		
Lucretia Crocker Fund	4,432.36		$ 909,541.86
Plant Funds:			
Rockefeller Foundation Contribution for New Laboratory Building	$500,000.00		
Interest Received on same during Year	8,721.67		
	$508,721.67		
Other Investment in Plant from Gifts and from Current Funds	377,290.73		
			886,012.40
Current Liabilities and Surplus:			
Mortgage on Gansett Property		$ 8,182.01	
Accounts-Payable		398.85	
Surplus,			

Balance, January 1, 1924		$427,309.99	
Add,			
Proceeds of Library and Reserve Fund Securities	9,715.24		
Balance of Income for Year—Exhibit B	23,904.52		
		$460,929.75	
Deduct,			
Book Value of Plant Assets transferred to "Plant Funds" above	377,290.73	83,639.02	
			92,219.88
			$1,887,774.14

EXHIBIT B

MARINE BIOLOGICAL LABORATORY, INCOME AND EXPENSE, FOR YEAR ENDED DECEMBER 31, 1924.

	Total		Net	
	Expense	Income	Expense	Income
Income, Endowment Fund		$ 33,656.58		$33,656.58
Donation for Expenses:				
Friendship Fund, Inc.		4,880.00		4,880.00
Others		25.00		25.00
Instruction	$ 7,516.39	10,095.00		2,578.61
Research	3,125.90	6,875.00		3,749.10
Biological Bulletin and Membership Dues	5,127.14	4,943.79	$ 183.35	
Supply Department, Schedule V	48,379.66	56,645.08		8,265.42
Mess Department	24,948.95	26,776.71		1,827.76
Dormitories Department	3,282.85	3,492.25		209.40
Interest and Depreciation charged to above Three Depts.	10,221.99			10,221.99
Dividends on Stock in General Biological Supply House, Inc.		976.00		976.00
Rent of Microscopes		319.50		319.50
Interest on Bank Deposits		103.54		103.54
Newman Cottage	122.85	150.00		27.15
Sundry Income		84.98		84.98
Maintenance of Plant:				
Maintenance of Buildings and Grounds	$ 6,121.19			
New Laboratory Expense	4,567.66			
Chemical Department	2,776.50			
Library Expenses	2,563.56			
Sundry Expenses	1,322.32			

Carpenter Department....	1,080.28			
Dexter House, Special....	971.35			
Truck Expenses.....	567.06			
Bar Neck Property.....	375.00			
Pumping Station.....	258.95			
Evening Lectures.....	111.41			
Janitor's House.....	11.77		20,727.05	
General Expenses:				
Administrative Expense...	$ 10,981.15			
Endowment Fund, Trustee	787.50			
Interest on Loans.....	386.84			
Bad Debts.....	346.51		12,502.00	
Reserve for Depreciation.....	$ 9,608.11		9,608.11	
		$149,023.43		$66,925.03
	$125,118.91	125,118.91	$43,020.51	43,020.51
Balance of Income carried to Current Surplus—Exhibit A.....		$ 23,904.52		$23,904.52

SCHEDULE I

MARINE BIOLOGICAL LABORATORY SCHEDULE OF SECURITIES HELD BY CENTRAL UNION TRUST COMPANY OF NEW YORK AS TRUSTEE UNDER AGREEMENT DATED JANUARY 22, 1924. DECEMBER 31, 1924.

Bonds.

Par Value		Cost
$ 25,000.	Chesapeake & Potomac Telephone Company of Virginia, 1st 30 Year S/F "A" 5s, due May 1, 1943; interest May and November 1.....	$ 23,812.50
*25,000.	Great Western Power Company, 1st Mortgage S/F 40 Year 5s, due July 1, 1946; interest January and July 1.....	25,000.00
*50,000.	Government of the Dominion of Canada, 30 Year 5s due May 1, 1952, interest May and November 1.....	50,000.00
25,000.	Home Long Distance Telephone Company, 1st S/F 20 Year 5s, due January 2, 1932; interest January and July 2...	24,031.25
*25,000.	Joint Stock Farm Loan Bonds, The Lincoln Joint Stock Land Bank of Lincoln, Nebraska, 5s due November 1, 1938; interest May and November 1.....	25,000.00
*50,000.	Illinois Bell Telephone Company, 1st and Refunding Mortgage "A" 5s due June 1, 1956; interest June and December 1.....	50,000.00
*10,000.	Indiana Steel Company, 1st Mortgage 5s due May 1, 1952, interest May and November 1.....	10,000.00
*25,000.	Indianapolis Gas Company of Indianapolis, Indiana, 1st Consolidated Mortgage, 5s due April 1, 1952; interest April and October 1.....	25,000.00

25,000.	Lehigh Valley Harbor Terminal Railway Company, 1st 5s due February 1, 1954; interest February and August 1.	24,187.50
50,000.	Mortgage Bond Company of New York, Series No. 4, 6s due November 1, 1933; interest May and November 1..	49,500.00
*10,000.	Nashville Florence & Sheffield Railway Company, 1st Mortgage 5s due August 1, 1937; interest February and August 1.....	10,000.00
*8,000.	New Castle Company, Delaware Highway Improvement 4½s due January 1, 1932; interest January and July 1..	8,000.00
*50,000.	National Tube Company, 1st Mortgage 5s due May 1, 1952; interest May and November 1.....	50,000.00
*10,000.	New Castle Company, Delaware Highway Improvement 5th Series 4½s due January 1, 1931; interest January and July 1.....	10,000.00
*10,000.	New Castle Company, Delaware Highway Improvement 5th Series 4½s due January 1, 1930; interest January and July 1.....	10,000.00
10,000.	Philadelphia, Baltimore and Washington Railroad Company, General "B" 5s due February 1, 1974; interest February and August 1.....	9,875.00
15,000.	Reading Company, General and Refunding "A" 4½s due January 1, 1997; interest January and July 1.....	13,403.75
*10,000.	Southern Railway Company, 1st Consolidated Mortgage 5s due July 1, 1994; interest January and July 1.....	10,000.00
*50,000.	State of Louisiana Port Commission Serial Canal 5s due July 1, 1958; interest January and July 1.....	50,000.00
*10,000.	Southern Public Utilities Company, 1st and ref. mortgage 30 Year 5s due July 1, 1943; interest January and July 1.	10,000.00
*12,000.	U. S. A. 2nd Liberty Loan 4½s due November 15, 1942; interest May and November 15.....	12,000.00
*25,000.	Virginian Railway Company, 1st Mortgage, 50 Year "A" 5s due May 1, 1962; interest May and November 1....	25,000.00
*25,000.	Waco, Texas, Sewerage Disposal Plant, 5s due January 1, 1948; interest January and July 1.....	25,000.00
25,000.	West Shore Railroad Company, Gtd. Registered 1st 4s due January 1, 2361; interest January and July 1.....	19,687.50

Real Estate Mortgages

30,000.	B/M Alva Realty Company, 1321/7 Amsterdam Avenue, 5½% due February 1, 1929, interest February and August 1.....	30,000.00
30,000.	B/M Alva Realty Company, 129 W. 56th Street, 5½% due January 28, 1927; interest January and July 28.....	30,000.00
50,000.	B/M Cordelia Realty Corporation, 47/51 E. 52nd Street, 5½% due December 5, 1928; interest June and December 1.....	50,000.00
50,000.	B/M S & L Bldg. Company, N. E. Corner 82nd Street and Broadway, 5½% due April 9, 1933; interest June and December 1.....	50,000.00

* Securities received from Friendship Fund, Inc., taken at Par Value. Total, $405,000.00.

50,000.	B/M M & H Friedel, 328/38 E. 46th Street, 5½% due January 23, 1929; interest January and July 23.....	50,000.00
50,000.	B/M Canebrake Realty Company, 708–12 Greenwich Street, 5½% due December 29, 1928; interest June and December 29.....	50,000.00
30,000.	B/M Spruce & William Street Realty Company, N. E. Corner Spruce and William Streets, 5½% due December 30, 1928; interest June and December 30.....	30,000.00
23,000.	B/M W. T. Slevin, 47 Murray Street, 5½% due August 1, 1926; interest February and August 1.....	23,000.00
22,600.	B/M Bertha Kahn, 594/6 Broadway, 5½% due March 11, 1929; interest March and September 11.....	22,600.00
$915,600.		
	Total, December 31, 1924, Exhibit A.....	$905,097.50

Schedule II

Marine Biological Laboratory, Lucretia Crocker Fund, December 31, 1924.

Investments

18 shares Vermont & Massachusetts Railroad Company.....	$2,416.50
3 shares American Telephone & Telegraph Company.....	504.04
4 shares Boston Consolidated Gas Company, Preferred.....	420.58
3 shares General Electric Company.....	349.55
16½ shares General Electric Company Special @ $11.00.....	181.50
4½ shares General Electric Company Special (Received as Stock Dividend)	
1 share Boston Elevated Railway Company, Second Preferred	133.00
Total, December 31, 1924—Exhibit A.....	$4,005.17

Cash Transactions for Year

Cash on Hand, January 8, 1924.....		$ 373.78
Received from Sale of Liberty Loan and American Telephone & Telegraph Company Bonds:		
Cost, as shown in Schedule I of Audit Report for 1923....	$494.75	
Gain on Sale.....	4.98	499.73
Received for Interest and Dividends.....		189.87
Received from Sale of Rights.....		3.56
		$1,066.94
Paid for Securities transferred from Reserve and Library Funds.	$564.75	
Paid for 1924 Scholarship.....	75.00	639.75
Balance on Hand, December 31, 1924—Exhibit A....		$ 427.19

SCHEDULE III

MARINE BIOLOGICAL LABORATORY CASH RECEIPTS AND PAYMENTS RESERVE AND LIBRARY FUNDS JANUARY 8, 1924 TO DECEMBER 31, 1924.

Reserve Fund:		
Cash on Hand, January 8, 1924		$ 782.93
Received from Sale of Securities,		
Cost as shown in Schedule I of Audit Report for 1923	$5,895.76	
Gain on Sale	951.15	6,846.91
Received for 12 shares General Electric Company, Special, transferred to Crocker Fund		132.00
Received for Interest and Dividends		226.93
		$7,988.77
Transferred to Laboratory General Cash Account		$7,988.77
Library Fund:		
Cash on Hand, January 8, 1924		$ 20.13
Received from Sale of Securities,		
Cost as shown in Schedule I of Audit Report for 1923	$1,957.81	
Gain on Sale	348.01	2,305.82
Received for Securities transferred to Crocker Fund: Cost	$ 362.38	
Gain on Transfer	70.37	432.75
Received for Interest and Dividends		97.46
Received from Sale of Rights		10.65
		$2,866.81
Transferred to Laboratory General Cash Account		$2,866.81

The Reserve Fund and the Library Fund were, as shown above, closed out during the year by order of the Executive Committee, the proceeds of the Reserve Fund being used for the acquisition of new property, and the proceeds of the Library Fund being used for the purchase of books.

Respectfully submitted,
LAWRASON RIGGS, JR.,
Treasurer.

V. REPORT OF THE ASSISTANT LIBRARIAN DECEMBER 31, 1924.

Along with the start of a new library building made a year ago, there has been a steady effort on the part of the Library Staff to so adapt their activities that, with the least expenditure of money and effort, our acquisitions and our new arrangements should fall into ready adjustment with the new and enlarged quarters. Even before the beginning of the year of 1924, a special sum had, at the request of the Assistant Librarian and of the Library Committee, been granted for the purchase of back sets—a sum of $400.00, this entirely outside the appropriation for the years 1923 and 1924. At the same time $350.00 had been granted for the employment of a secretary for at least a part of the year 1924. A start in purchasing back sets of serials was therefore well begun by January 1, 1924 and on the first of May the services of a secretary-stenographer were secured. With this kind of help, the Assistant Librarian has felt that work of real value to the Library has gotten under way.

The Assistant Librarian was also authorized to anticipate the use of a sum of $4,000.00 that would be available before the expiration of the year 1924 from the accumulation of the endowment fund; this was used in the purchase of back sets in the early spring that would, a few months later, have been unavailable. These were German sets for sale in this country, not as yet affected by the great jump made in German prices. During the late spring, extensive orders were placed in England with Heffer, and still later information showed France and French sets to be the best sales available. Certain sets of American journals were ordered at this same time, at high prices, but only where sets were out of print and no lessening of price could ever be anticipated. A detailed listing of the sets ordered and come into our actual possession during the year 1924 will follow later with the statement of other acquisitions.

On September 20, the Secretary of the Executive Committee handed a statement to the Assistant Librarian authorizing a provisional budget of $6,500.00 for the year 1925 as well as the use of a further sum of something over $2,500.00 for the year

1924–25 from the sale of the Library Fund securities. These actually realized $2,866.86. The Assistant Librarian was further assured by this same statement of the Executive Committee that the secretary would be retained and that early in the year 1925 the salary for an assistant would be available, besides a small sum for "man labor," over and above the sums stated on the budget and the $4,000.00 above referred to as a special sum. Along with this definite backing, the Assistant Librarian was also assured that any reasonable distribution for the two years of 1924–25 expenditures could be mapped out that seemed wise. For this reason and because of the practicability of running the two years together the provisional distribution of the total sum for 1924–25 of about $15,000.00 ($1,750.00 having been appropriated for expenditures aside from salaries for 1924) has been made as follows: current subscriptions, $3,000.00; books, $1,300.00; binding $2,000.00; back sets, $8,000.00; express, $200.00; supplies, $500.00.

A feature as interesting as that of securing back sets of our current serials, is that of securing new current subscriptions. The sum for this purpose we propose to double in the year 1925 over 1924 which latter was $1,000.00, thus spending $3,000.00 for the two years. A list of those now already undertaken for the years 1924 and 1925 will be given later. The negotiation for new exchanges in current serials is being carried on with success most encouraging for the effort made. The new exchanges that have been secured for the BIOLOGICAL BULLETIN, already begun for the years 1924 and 1925, are also given below.

With the larger funds available in these two years a really generous increase in the amount spent for books seemed right, especially since our attitude of favoring serials over books will for obvious reasons continue. And there are many gaps in our reference books in both systematic and morphological works as well as strictly physico-chemical lines. Important works in each of these lines have been purchased as is seen in the summary. There have been many gifts of books during the year. Very especial appreciation we hope may be conveyed to the authors of books who have remembered the users of the Library; and to the publishers who have so wisely and generously seen the advantages that the Library offers for the spreading of news as to a good book.

These gifts have all been acknowledged personally and a full list follows at the end of the report.

With the anticipated increase in space and especially the anticipated assistance to be given by another member of the Library Staff, trained in science and language, a special plea for reprints was sent at the end of December to each member of the following societies: American Physiological Society; American Society of Biological Chemists; American Society of Pharmacology and Experimental Therapeutics; American Society for Experimental Pathology; Ecological Society of America; Botanical Society of America; American Society of Zoölogists; American Society of Anatomists; American Society of Naturalists.

The return postal cards have shown how generous and co-operative the spirit of the scientist is. We feel great encouragement in regard to building up complete sets of reprints. We should have asked each author to send a bibliographic list of his reprints which could be filed in with such of his reprints as we have represented. This will have to be undertaken in the future. A count of the reprints acquired by the Library for 1924 will be deferred until the year 1925 and will be incorporated with the report for that year.

It gives me pleasure to express here my appreciation of Miss Deborah Lawrence's assistance in the Library since September 1st as Secretary. She gives every promise of accurate and business-like executive. Miss Frances Childs performed this same duty well during the summer, and would have been continued except that she undertook the summer work solely with the provision that she be released to pursue her studies in business training on September 1st. At this same time it is also a pleasure to announce that Miss Margaret Olmsted, Vassar, '24, with special training in physics and chemistry, as well as in French and German, will begin her duties as assistant in the Library on February 2nd, 1925. At this same time also I would greatly like to express my appreciation for the many suggestions that the Library Committee have given during the year. The sympathetic co-operation that each member has shown toward the work in the Library adds the authority as well as the balance of the scientist's point of view.

The Library now contains some 13,000 volumes, about eight-

ninths of these being serial publications, mostly bound, and the remainder chiefly books. The reprints are about 9,800 with several hundreds besides these in our possession but so far uncatalogued. The number of currently received serials is about 332. Of these 132 are paid subscriptions and 200 are received by exchange for the Biological Bulletin, by gift or by loan. Forty-two subscriptions have been newly placed by purchase for the years 1924–25, and thirty-two newly secured by exchange. These are as follows:

Paid subscriptions: new in 1924: *Annales de l'Institut Pasteur; Archiv für experimentelle Pathologie und Pharmacologie; Chemical Reviews; Genetica; Ecology; Journal of the Chemical Society; Journal of Immunology; Journal of Medical Research; Journal of Scientific Instruments; Revue algologique; Revue générale d'histologie; Science Abstracts; Zeitschrift für Zellen- und Gewebelehre (Abteilung B. Zeitschrift für wissenschaftliche Biologie); Zeitschrift für vergleichende Physiologie (Abteilung C. Zeitschrift für wissenschaftliche Biologie).*

Paid subscriptions: new in 1925: *American Journal of Hygiene; Annals of Applied Biology; Annales de parasitologie humaine et comparé; Archives de morphologie générale et expérimentale; Archives de parasitologie; Brain; British Journal of Experimental Pathology; Centralblatt für Bakteriologie; Ergebnisse und Fortschritte der Zoologie; Flora; Allgemeine botanische Zeitschrift; Jahresberichte über die Fortschritte der Anatomie und Entwicklungsgeschichte; Journal de l'anatomie et de la physiologie; Journal de chimie physique; Journal de pharmacie et de chemie; Journal de physic; Journal of Botany; Journal of Experimental Pathology; Journal of Pathology and Bacteriology; Journal of the Washington Academy of Science; Kolloid-Zeitschrift: Beihefte; Quarterly Cumulative Index of Current Medical Literature; Ray Society Publications; Scientia; Tables annuelles de constantes; Virchow's Archiv für pathologische Anatomie und Physiologie und für klinische Medecin; Zeitschrift für Immunitats-Forschung; Zoologischer Bericht.*

Exchanges: new in 1924: *Acta hori bergiani; Annales scientifiques de l'Université de Jassey; Archives internationales de pharmacodynamie; Archives of internal medicine; Australian journal of experimental biology and medical sciences; Biologisches*

Centralblatt; Bulletin d'histologie appliquée à la physiologie, et à la pathologie, et de technique microscopique; Bulletin de l'Academie royale de Belgique; Bulletin de la société belge de biologie; Bulletin de la société royale des sciences médicales et naturelles de Bruxelles; Bulletin internationale de l'Academie des Sciences; Internationale Revue der gesamten Hydrobiologie und Hydrographie; Journal of Metabolic Research; Journal of the Linnean Society: Zoölogy; Monitore zoologico italiano; Nyt Magazin für Naturwidenskaberne; Osterreichische botanische Zeitschrift; Philippine journal of science; Recueil trauvaux botanique néerlandais; Publications of the Zoological Museum of Russia; Studies from the Plant Physiological Laboratory of Charles University, Prague; Transactions and Reports of the Royal Society of Australia; Transactions of the Connecticut Academy of Arts and Science.

Exchanges: new in 1925: *Acta phytochimica; Botanisches Archiv; Dansk Botanisk Tidskrift; Fermentforschung; Japanese Journal of Biochemistry; Medical Science: Abstracts and Reviews; Naturae Novitates; Ofversigt af Finska Vetenskaps-Societates, Förhanlingar*, and *Commentationes*, and *Acta; Zeitschrift für wissenschaftliche Zoologie.*

Besides currently received serials, there are on the shelves, sets, more or less complete, of serials to the number of about two hundred and fifty-three that have now ceased publication.

The following serials have been completed as sets by purchase as indicated, the expenditure for these having been about $4,251.80: *Acta horti Bergiani*, volumes 1–6, 1891–1919; *Annales de l'Institut Pasteur*, volumes 15–17; 24–38; *Annales des sciences naturelles: Zoologie*, series 4 to 9 filled in; (a few early volumes still missing); *Annals of Applied Biology*, volumes 1–10, 1914–24; *Annals of Botany*, 3–21; *l'Année biologique*, 1–21; *Annual Report of the Progress of Chemistry*, by volume 8; *Archives d'anatomie microscopique*, 1–16; *Archives de zoologie expérimentel et générale*, 32 scattered volumes; *Archives internationales de physiologie*, 1–14; *Archivio di farmacologia sperimentale et scienze affini*, 1–26; *Bibliographia Zoologica*, by volumes 30, 31, 32, and 34; (2 volumes still lacking); *Biochemische Zeitschrift*, 1–55, 1906–1913; 72–100, 1916–1919; *British Journal of Experimental Pathology*, 1–5, 1920–24; *Bulletin de l'Institut Pasteur*, 1–17, 1903–1909; *Ecology*, 1–4, 1920–23; *Fauna und Flora des Golfes von Neapel*,

monographs 26–35a, 1901–1923; *Folia Neurobiologica*, 2 and 3–12, 1909–17 (volume 1, 1908, still lacking); *Harvey Lectures*, 1–16, 1905–1922; *Journal de physiologie et de pathologie générale*, 1–15; 17 (volumes 16 and 18 still lacking); *Journal of immunology*, volumes 1–8; *Journal of Physical Chemistry*, volumes 1–24; *Journal of the American Chemical Society*, 32–42, 1910–1920; *Journal of the Chemical Society* (*London*), volumes 45–124, 1884–1923; *Nuova Notarisia*, volumes 1–28, 1890–1918; *Physical Review*, 1—series 2, 16, 1893–1920; *Proceedings of the Academy of Natural Sciences of Philadelphia*, 41 volumes scattered thoughout the set; *Proceedings of the Royal Society of London*, 45–75, 1890–1905; *Psychobiology*, 1–2; *Quarterly Cumulative Index of Current Medical Literature*, 1 and 5–9 (2–4 still lacking); *Quarterly Journal of Microscopical Science*, volumes 18 and 19; *Revue générale d'histologie*, 1–3, 1904–1911; *Science Abstracts*, 1–26, 1898–1923; *Zeitschrift für physikalische Chemie*, 1–104, 1887–1923; *Zentralblatt für Zoologie, Allgemeine und experimentelle Biologie*, 1–6, 1912–1918. Many odd volumes besides these have been secured and paid under this sum above mentioned.

Through exchange of back sets for the Biological Bulletin, these sets have been secured in 1924: *Annales scientifiques de l'Université de Jassey*, 1–12, 1900–1923; *Annuaire du museum zoologique de l'Academie Imperial des Sciences de la Russie*, 9–13, 1914–20; *Archives internationales de pharmacodynamie*, volumes 1–29; *Bulletin de la classe des sciences, l'Academie royale de Belgique*, series 5, volumes 5–9, 1919–23; *Fauna of Russia*, volumes 1914–19; *Monitore zoologico italiano*, 1907–1924; *Nouvelles archives du Museum d'Histoire Naturelle*, Paris, series 2, 1—series 5, 6, 1878–1914; *Nyt magazin für Naturvidenskaberne grumdlagt au den physiographiske Forening, Christiania*, volumes 46–60, 1909–1923; *Ofversigt af Finska Venteskaps-Societetens; Förhandlingar*, volumes 45–64; *Osterreichische botanische Zeitschrift*, volumes 71–74, 1922–24; through exchange of duplicates of the Museum of Comparative Zoölogy publications and of the Boston Society of Natural History publications, the Library has, this year, also, filled in nearly all the bad gaps that existed, so that these sets are now practically complete.

The more important year's purchases of books and sets of reference works as regarded from the view-point of cost, are as

follows: *Vergleichende Anatomie des Nervensystems*, by C. U. Ariêns Kappers und Droogleever Fortuyn; Barnes and Heald: *Analytic key to mosses of the United States;* Berlese, A.: *Gli Insetti;* Daniel, John Franklin: *The Elasmobranch fishes;* De Toni: *Sylloge Algorum*, volume 6; Helmholtz: *Handbuch der physiologischen Optik;* Jellinek, K.: *Physikalische Chemie der homogenen und heterogenen Gasreaktionen;* Leitgeb, H.: *Untersuchungen uber die Lebermuse;* Morgan, T. H.: *Regeneration;* Morse, H. N.: *Investigations in Osmotic pressure; Ouvres* de Pasteur: *Dissymetrie moleculaire, Fermentations et generations dites spontanées, Études sur le vinaigre et sur le vin;* Parker and Haswell: *Text-book of Zoölogy* 3d edition; *Plankton Expedition: Ergebnisse der in der Atlantisch Ozean*, etc.; Sars: *Crustacea of Norway*, 1–3; *United States Catalogue of 1912–1917;* Wiesner, Julius von and Moeller, J.: *Die Rohstoffe des Pflanzenreiches;* Williams, L. W.: *Anatomy of the Common Squid;* Wolle, Francis: *Green Algae of the United States;* Wood: *Physical Optics.*

Through gifts we have received as follows: new current serials and to continue: *American Journal of Photography* (now issued as *Camera*), *British Journal of Photography, Journal of the Photographic Institute, Journal of the Optical Society of America, and Review of Scientific Instruments, Photographic journal of the Royal Society of London*, from Dr. Pond; *Public Health Report*, from the United States Health Service; *Monographs*, from Cold Spring Harbor; *Bulletin of the University of Wisconsin*, and *Wisconsin Studies in Science*, at the request of Professor Guyer.

From the publisher, Blakiston: Atwood, W. H.: *Problems, Projects, and Experiments in Biology;* and *Comparative Vertebrate Dissection;* Clark, A. J.: *Applied Pharmacology: Scientific Evidence for Therapeutic Active Drugs;* Hawk, Philip B.: *Practical Physiological Chemistry;* Palladin, *Plant Physiology;* Pratt, H. S.: *Land and Freshwater Vertebrate Animals of the United States;* from the publisher, Saunders: Howell: *Physiology;* Lusk, Graham: *Elements of the Science of Nutrition* (at the request of the author); Mallory and Wright: *Pathological Technique;* Wells, H. Gideon: *Chemical Pathology;* from the New Haven Yale University Press: Woodruff, L. L.: *Development of the Sciences* (at the request of the author); from the publisher, Wiley: Underhill, Frank P.: *Manual of Selective Biochemical Methods; San*

Francisco Bay Marine Piling Survey Reports, from the Committee; from the publisher, Macmillan: Smith, Gilbert M.: *A Textbook of General Botany;* from Newman, Horatio Hackett: *Outlines of General Zoölogy*, and *Evolution;* from the Cape Cod Chamber of Commerce: *Special Report on Population and Resources of Cape Cod;* from H. S. Jennings: *Life and Death, Heredity and Evolution in Unicellular Organisms;* from Dr. Pond: Fischer, Max: *Uber den Abbau von Chlorophyll und Blutforbstaff;* from Lusk, Graham: *Science of Nutrition;* from Fischer, M.: *Oedema;* from Lillie, R. S.: *Protoplasmic Action and Nervous Action;* from Mrs. Jacques Loeb: *Regeneration from a Physico-chemical Viewpoint;* from Price, Weston A.: *Dental Pathology;* through Professor Tower from the American Museum of Natural History, Dean, Bashford: *A Bibliography of Fishes;* from Loeb, Leo: *Edema;* from Winge, Herluf: *Pattedyr-Slaegter;* from Schroder, Paul: *Introduction to the Histology and Histopathology of the Nervous System;* from the National Research Council: Atwood and Johnson: *Marine Piling Investigations;* from Hyman, L. H.: *Laboratory Manual of Elementary Zoölogy;* from Wheeler, Wm. M.: *Social Life among the Insects;* Professor Wheeler sent to us several boxes of reprints and odd volumes and numbers of journals also, which we were glad to get. Mrs. Montgomery presented some twelve books to the Library.

VI. THE DIRECTOR'S REPORT.

TO THE TRUSTEES OF THE MARINE BIOLOGICAL LABORATORY.

Gentlemen: I beg to submit herewith a report of the thirty-seventh session of the Marine Biological Laboratory for the year 1924.

1. *Attendance.*—As stated in the annual report for 1923 it was decided to set definite numerical limits to each of the courses of instruction and this was accordingly done and acted on in 1924. The result was the admission of only 134 students selected from almost twice the number of applicants. These students were distributed among the classes as shown in the tabular view of attendance (p. 37), each class being registered up to its full authorized number. The selection from among the applicants is

made by the head of each course of instruction on a given date, May 15 of each year, on the basis of a detailed application and letters of recommendation.

The number of investigators was 194, the largest registration in the history of the Laboratory. It is interesting to note that 70 of these were "under instruction," that is for the most part graduate students from University laboratories. The opportunity that is afforded these students of comparing the teachings and methods of the various University laboratories is a great benefit educationally for them. The large attendance of workers of this age augurs well for the future of the Laboratory which must depend for its growth on the development and maintenance of the devotion to its interests of successive generations of scientific workers.

2. *Library.*—The report of the Acting Librarian is given in another place. It details the plans and the means available for enlargement of the library, which we should now set down as one of the principal ends to be emphasized in the development of the Laboratory during the next few years. Next to providing the materials for investigation, and facilities of modern and adequate type for the work of research itself, there is no material service that the Laboratory can render of greater importance than a thoroughly good working library. To that end a wing of the new building is devoted with stack space for 100,000 volumes. If this capacity be compared with the present possessions of the library, 13,000 bound volumes and about 10,000 reprints and pamphlets, it will be realized that our efforts on behalf of the library need not relax for lack of space for some years to come. The Acting Librarian is to be congratulated on getting an active policy of expansion into operation before the new quarters are entirely ready.

3. *The Report of the Treasurer* (pp. 5–12).—Particular interest attaches to the report of the Treasurer this year because it includes the new endowment funds and the results of building operations as well as the customary current accounts. The assets of the Laboratory are thus of quite a different order of magnitude at the end of 1924 as compared with previous years: $1,887,774.14 on December 31, 1924 as compared with $445,504.69 on December 31, 1923. Of this amount $909,541.86 represent

income-yielding securities, the remainder being in plant assets and current assets. An additional sum of at least $200,000.00 is available from the Friendship Fund for completion of the building and its equipment, which will increase the assets of the Laboratory to considerably over $2,000,000.00. The securities belonging to the "Reserve Fund" and the "Library Fund" of previous reports were sold during the year at considerable profit as compared with book value; the proceeds from the Reserve Fund were applied on the purchase of the Hubbard property, and the money from the Library Fund was used for purchase of books. These funds were accumulated from small savings of many years past for the purposes for which they were finally used. In the case of the "Reserve Fund" it was felt that the ownership of such a strategically placed piece of property as the Hubbard lot was worth much more to the Laboratory than the securities in the fund. The timeliness of conversion of the Library Fund into books requires no comment.

It will be observed that the current accounts of the year 1924 show a considerable surplus ($23,904.52) of income over expense (Exhibit B of Treasurer's report). The operations of the year were planned on the usual scale, without reference to the new endowment fund, which was, however, paid in and invested early in the year. The income, which was considerably increased by an unusually good showing of the Supply Department (Exhibit B) was thus largely in excess of requirements in spite of an additional grant to the Library during the year, and repayment of loans totaling $6,100.00. This surplus enables us to start the operation of the enlarged plant with a considerable degree of confidence. It should be said also that the estimates for the year 1925 show a slight excess of income over expense including some unusual items. The net impression of a study of the Treasurer's report is that the Laboratory has an adequate financial foundation for its present needs, but that the same rigid economy will be needed in the future as in the past.

4. *Building Progress.*—As stated in the last report the Rockefeller Foundation made an appropriation of $500,000.00 for the new building; Mr. C. R. Crane also gave a pledge on behalf of the Friendship Fund to contribute whatever additional money was needed, according to the architects' plans and specifications, for

completion and equipment of the building. When the bids for the building were received and the estimates for equipment added the total requirements were found to be $748,886.71 divided as follows:

General Construction, Geo. A. Fuller Co.	$478,120.00
Plumbing, C. H. Cronin, Inc.	54,860.92
Heating and ventilating, Cleghorn Co.	31,534.00
Electric work, Hixon Electric Co.	65,875.00
Elevator and book lift, Otis Elevator Co.	6,970.00
Architects and engineers' commissions	36,526.79
Furniture, equipment, etc.	65,000.00
Alterations in course of construction	10,000.00
	$748,886.71

The Friendship Fund accordingly appropriated a sum not in excess of $248,886.71, and not in excess of the cost of the items enumerated, above the contribution of $500,000.00 for building by the Rockefeller Foundation and interest on this fund. The Building Committee has made every effort to keep within the available funds with the result now clearly in sight of entirely avoiding the necessity of any additional payment for alterations in the course of construction and of some probable slight savings in other directions. The great care with which the plans and specifications were prepared by the architects, and especially Dr. Drew's constant oversight of the building operations and purchase of equipment have been notable factors in the achievement of this result.

It has certainly very rarely happened that an institution has received such signally generous treatment and confidence as the Marine Biological Laboratory has received from the donors of the building fund. The action of the Rockefeller Foundation in paying over their entire contribution in cash before building operations were begun amounted to an increase of their contribution by the interest received during construction. The action of the Friendship Fund in guaranteeing the completion and equipment of the Laboratory insured the hearty coöperation of the other contributors, created a notable spirit of confidence, and aroused our own organization to the highest state of morâle.

Ground was broken for the new building on March 20, 1924. No serious difficulties were experienced during the course of con-

struction which now seems likely to be completed within a year from the date of beginning.

5. *Research Rooms.*—The charge for use of a research room during the summer session has remained at $100.00 since 1888. The Executive Committee reviewed the situation in 1924 and decided to make no change in the case of the wooden buildings, but in the case of the research rooms of the brick buildings, which are more than twice the size and much more amply supplied with fixtures, it seemed reasonable, and wise from the point of view of all members of our coöperative organization, to ask increased appropriations from the coöperating institutions using them. Accordingly a basic charge of $200.00 has been established for the summer season with the understanding that two persons may occupy such a room. This should be regarded as a first step towards an equitable arrangement that will permit the most efficient operation of the building for research purposes.

6. *Biological Bulletin.*—The forty-seventh volume of the BIOLOGICAL BULLETIN was completed in 1924. It had been maintained at about a constant size since its establishment, two volumes with about 650–700 pages per year. Lately in common with many other biological research journals it had been falling behind in promptness of publication so that about a year elapsed between receipt of manuscripts and their appearance in print. The cost of enlarging it so as to keep up with manuscripts offered was greater than the Laboratory could well afford. It has also become a very valuable medium of exchange for the library as stated in Mrs. Montgomery's report. It was therefore decided to enlarge it to 900 pages a year, about 75 pages per number and at the same time to raise the subscription price from $6.00 to $9.00 per year. Correspondingly the fees of members of the Corporation, who receive the BULLETIN without other subscription, were increased from $4.00 to $6.00 per year. The increase in size began with the first issue of 1925, and it is already apparent that the passage of a manuscript to publication will be reduced to at most six months, and it is hoped to a still shorter period. There has been no significant loss of subscriptions or of membership in the Corporation in consequence of the increased cost.

7. *Membership of the Board of Trustees.*—At the meeting of the

Corporation held August 12, 1924 Professor R. A. Harper of Columbia University was elected a member of the class of 1928, and the seven members of the class of 1924 were reëlected to serve until 1928.

The following resolution in memory of Jacques Loeb, member of the Laboratory since 1893 and of the Board of Trustees since 1897, was adopted by the Board of Trustees and by the Corporation of the Marine Biological Laboratory at their meetings on August 12, 1924:

By the death of Dr. Jacques Loeb the world has lost one of the great men of his generation; Biology has lost one of the finest intellects that has ever been devoted to this branch of science; this Laboratory has lost one of its most eminent members. He stood out among his fellows as an investigator, as a teacher, and as a cultivated gentleman broadly interested in all aspects of nature and all the activities of men.

As an investigator he was tireless in energy, ingenious in experimentation and exceptionally gifted in insight. He lost little time on false leads, but rather blazed his trail straight into new territory and attained his objective by simple and crucial experiments.

He brought to his work a broad knowledge of related sciences. In the latest advances of chemistry and physics he was always informed, and his researches showed the breadth of his reading and the solid character of his scholarship.

He had a poet's imagination held in check by practical and mathematical faculties of high order. Consequently his hypotheses were at once brilliant and founded on the best physico-chemical data available. He was ready to change his theories as new facts were discovered. He believed that explanations of phenomena must be expressible ultimately in mathematical terms. He profoundly influenced General Physiology not only by his theories and experimental results but also, quite as much, by the emphasis he laid upon the quantitative method.

Professor Loeb came to Woods Hole first in 1892. The epoch-making discovery of artificial parthenogenesis was made at this laboratory. The antagonistic action of ions was demonstrated here. Many other researches which have influenced biological thought were carried on here and may be noted in the long list of papers and books which constitute his best monument. He founded the course in General Physiology at Woods Hole in 1893 and directed it for several years. He was a trustee from 1897 to his death. From 1910 he directed the branch laboratory of the Rockefeller Institute in coöperation with Marine Biological Laboratory.

As a teacher he was enthusiastic and inspiring. His lectures were in advance of the times and full of suggestions for research. With his graduate students he was helpful and friendly and at the same time critical and stimulating. Those who were his students know how enormously they profited by his inspiring personality.

As a man his interests were well-nigh universal. He found time to make himself familiar with a large literature. He enjoyed music and all the arts. He was interested in economics, sociology and government. His "Mechanistic Conception of Life" is an important contribution to Philosophy and Psychology.

He was a kindly man. He was a lovable man. He hated war and all sham. He had an incisive sense of humor and loved a harmless joke. He was the center of any company and he had many friends.

This is the man we have lost. Woods Hole is not the same without him, but the inspiration of his work remains in our midst.

To his family we extend our sympathy and on the pages of our records we inscribe this memorial.

There are included as parts of this report the following addenda:

1. The Staff, 1924.
2. Investigators and Students, 1924.
3. Tabular View of Attendance.
4. Subscribing and Coöperating Institutions, 1924.
5. Evening Lectures, 1924.
6. Members of the Corporation.

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1. THE STAFF, 1924.

FRANK R. LILLIE, *Director*, Professor of Embryology, and Chairman of the Department of Zoölogy, The University of Chicago.

GILMAN A. DREW, *Assistant Director*, Marine Biological Laboratory.

ZOÖLOGY

I. INVESTIGATION

GARY N. CALKINS, Professor of Protozoölogy, Columbia University.

E. G. CONKLIN, Professor of Zoölogy, Princeton University.

CASWELL GRAVE, Professor of Zoölogy, Washington University.

H. S. JENNINGS, Professor of Zoölogy, Johns Hopkins University.

FRANK R. LILLIE, Professor of Embryology, The University of Chicago.

C. E. MCCLUNG, Professor of Zoölogy, University of Pennsylvania.

S. O. MAST, Professor of Zoölogy, Johns Hopkins University.

T. H. MORGAN, Professor of Experimental Zoölogy, Columbia University.

G. H. PARKER, Professor of Zoölogy, Harvard University.

E. B. WILSON, Professor of Zoölogy, Columbia University.

II. INSTRUCTION

ROBERT H. BOWEN, Assistant Professor of Zoölogy, Columbia University.

EDWARD F. ADOLPH, Instructor in General Physiology, University of Pittsburgh.

HORACE B. BAKER, Instructor in Zoölogy, University of Pennsylvania.

J. A. DAWSON, Instructor in Zoölogy, Harvard University.

S. W. GEISER, Assistant Professor of Zoölogy, Washington University.

CHRISTIANNA SMITH, Assistant Professor of Zoölogy, Mount Holyoke College.

B. H. WILLIER, Instructor in Zoölogy, The University of Chicago.

DONNELL B. YOUNG, Assistant Professor of Biology, Carleton College.

PROTOZOÖLOGY

I. INVESTIGATION

(*See Zoölogy*)

II. INSTRUCTION

GARY N. CALKINS, Professor of Protozoölogy, Columbia University.

LOUISE H. GREGORY, Associate Professor of Zoölogy, Columbia University.

FLORENCE DE L. LOWTHER, Instructor in Zoölogy, Barnard College.

EMBRYOLOGY

I. INVESTIGATION

(*See Zoölogy*)

II. INSTRUCTION

HUBERT B. GOODRICH, Professor of Biology, Wesleyan University.

BENJAMIN H. GRAVE, Professor of Biology, Wabash College.

CHARLES PACKARD, Assistant Professor, Peking Union Medical College.

HAROLD H. PLOUGH, Associate Professor of Biology, Amherst College.

CHARLES G. ROGERS, Professor of Comparative Physiology, Oberlin College.

PHYSIOLOGY

I. INVESTIGATION

HAROLD C. BRADLEY, Professor of Physiological Chemistry, University of Wisconsin.

WALTER E. GARREY, Professor of Physiology, Tulane University.

RALPH S. LILLIE, Professor of General Physiology, The University of Chicago.

ALBERT P. MATHEWS, Professor of Biochemistry, The University of Cincinnati.

II. INSTRUCTION

MERKEL H. JACOBS, Professor of General Physiology, University of Pennsylvania.

WILLIAM R. AMBERSON, Assistant Professor of Physiology, University of Pennsylvania.

FRANK P. KNOWLTON, Professor of Physiology, Syracuse University.

REYNOLD A. SPAETH, Associate in Physiology, School of Hygiene and Public Health, Johns Hopkins University.

BOTANY

I. INVESTIGATION

S. C. BROOKS, Department of Public Health, Washington, D. C.

EDWARD M. EAST, Professor of Experimental Plant Morphology, Harvard University.

ROBERT A. HARPER, Professor of Botany, Columbia University.

E. NEWTON HARVEY, Professor of Physiology, Princeton University.

WINTHROP J. V. OSTERHOUT, Professor of Botany, Harvard University.

JACOB R. SCHRAMM, Professor of Botany, College of Agriculture, Cornell University.

II. INSTRUCTION

IVEY F. LEWIS, Professor of Biology, University of Virginia.

TRACY E. HAZEN, Associate Professor of Botany, Barnard College, Columbia University.

WILLIAM RANDOLPH TAYLOR, Assistant Professor of Botany, University of Pennsylvania.

WILLIAM H. WESTON, JR., Assistant Professor of Cryptogamic Botany, Harvard University. (Absent 1924.)

LIBRARY

——— ———, Librarian

PRISCILLA B. MONTGOMERY (Mrs. Thomas H. Montgomery, Jr.), Assistant Librarian, in charge.

CHEMICAL SUPPLIES

OLIVER S. STRONG, Associate Professor of Neurology, Columbia University, New York City, Chemist.

SUPPLY DEPARTMENT

GEORGE M. GRAY, Curator.
THOMAS M. DOUTHART, Assistant Curator.
JOHN J. VEEDER, Captain.
E. M. LEWIS, Engineer.
A. W. LEATHERS, Head of Shipping Department.
MILTON B. GRAY, Collector.
A. M. HILTON, Collector.
J. MCINNIS, Collector.

F. M. MACNAUGHT, Business Manager.
HERBERT A. HILTON, Superintendent of Buildings and Grounds.

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2. INVESTIGATORS AND STUDENTS, 1924.

ZOÖLOGY—Independent Investigators.

ADDISON, WILLIAM H. F., Professor of Histology and Embryology, University of Pennsylvania.
APPLETON, JOSEPH L., Jr., Professor of Microbiology and Bacteriopathology, Evans Institute, University of Pennsylvania.
AZUMA, RYOTARO, Physiological Laboratory, Tokio Imperial University.
BAGG, HALSEY J., Associate in Biology, Cornell University Medical College.
BAKER, HORACE BURRINGTON, Instructor, University of Pennsylvania.
BIGELOW, ROBERT PAYNE, Professor of Zoölogy, Massachusetts Institute of Technology.
BONNIER, GERT, University of Stockholm, Stockholm, Sweden.
BOSCHMA, HILBRAND, Chief Assistant in Zoölogy, University of Leyden.
BOWEN, ROBERT H., Assistant Professor of Zoölogy, Columbia University.
BREITENBECHER, J. K., Associate Professor of Zoölogy, University of Oklahoma.
BRIDGES, CALVIN B., Research Assistant, Carnegie Institution of Washington.
BUDINGTON, ROBERT A. Professor of Zoölogy, Oberlin College.
BURNS, ROBERT KYLE, JR., Assistant in Zoölogy, Yale University.
CALKINS, GARY N., Professor of Protozoölogy, Columbia University.
CAROTHERS, E. ELEANOR, University of Pennsylvania.
CHAMBERS, ROBERT, Professor of Microscopic Anatomy, Cornell University Medical College.
CLARK, E. R., Professor of Anatomy, University of Georgia.
CLARK, ELEANOR L., Research worker, University of Georgia.
CONKLIN, EDWIN GRANT, Professor of Biology, Princeton University.
COPELAND, MANTON, Professor of Biology, Bowdoin College.
DAWSON, JAMES A., Instructor in Invertebrate Zoölogy, Harvard University.
DETWILER, S. R., Assistant Professor of Zoölogy, Harvard University.
DOLLEY, WM. LEE, JR., Professor of Biology, Randolph-Macon College.
DONALDSON, HENRY HERBERT, Professor of Neurology, The Wistar Institute.
DREW, GILMAN A., Assistant Director, Marine Biological Laboratory, Woods Hole, Mass.
GLASER, OTTO CHARLES, Professor of Biology, Amherst College.
GOLDFARB, A. J., College of the City of New York.
GOODRICH, HUBERT BAKER, Professor of Biology, Wesleyan University.

GRAVE, BENJAMIN H., Professor of Zoölogy, Wabash College.
GRAVE, CASWELL, Professor of Zoölogy, Washington University.
GREGORY, LOUISE HOYT, Associate Professor of Zoölogy, Barnard College, Columbia University.
HANCE, ROBERT T., University of Pennsylvania.
HEILBRUNN, LEWIS V., Assistant Professor of Zoölogy, University of Michigan.
HENTSCHEL, CHRISTOPHER CARL, King's College, London.
HESS, WALTER N., Johnston Scholar, Johns Hopkins University.
HIBBARD, HOPE, Associate Professor of Zoölogy, Elmira College.
HOGUE, MARY J., Professor of Bacteriology, North Carolina College for Women.
HUXLEY, JULIAN SORELL, Senior Demonstrator in Zoölogy, Oxford University.
HYMAN, LIBBIE HENRIETTA, Research Assistant, University of Chicago.
JENNINGS, HERBERT S., Professor of Zoölogy, Johns Hopkins University.
JUST, ERNEST E., Professor of Zoölogy, Howard University.
KINDRED, JAMES E., Assistant Professor of Histology and Embryology, University of Virginia.
KNOWER, HENRY MCELDERRY, Professor of Anatomy, University of Cincinnati.
KOMAI, TAKU, Assistant Professor of Zoölogy, Kyoto Imperial University.
LANCEFIELD, DONALD E., Assistant Professor in Zoölogy, Columbia University.
LANGE, MATHILDE M., Head of the Department of Biology, Wheaton College.
LILLIE, FRANK R., Chairman, Department of Zoölogy, University of Chicago.
LYNCH, RUTH STOCKING, Assistant in Graduate Zoölogy, Johns Hopkins University.
MCCLUNG, CLARENCE E., Director of Zoölogical Laboratory, University of Pennsylvania.
MARTIN, EARL A., Assistant Professor, College of the City of New York.
MAST, SAMUEL OTTMAR, Professor of Zoölogy, Johns Hopkins University.
MAVOR, JAMES W., Professor of Biology, Union College.
METCALF, MAYNARD M., 128 Forest St. Oberlin, Ohio.
METZ, CHARLES W., Investigator, Carnegie Institution, Cold Spring Harbor.
MORGAN, T. H., Professor of Experimental Zoölogy, Columbia University.
MORGAN, LILIAN V., 409 W. 117th St., New York City.
MORRILL, CHARLES V., Associate Professor of Anatomy, Cornell University Medical College.
PACKARD, CHARLES, Associate in Zoölogy, Crocker Laboratory, Columbia University.
PAPANICOLAO, GEORGE N., Assistant Professor in Anatomy, Cornell University Medical College.
PLOUGH, HAROLD H., Professor of Biology, Amherst College.
RAND, HERBERT W., Associate Professor of Zoölogy, Harvard University.
RENYI, GEORGE S., Assistant Professor, University Medical College, Budapest.
ROGERS, CHARLES G., Professor of Comparative Physiology, Oberlin College.
SMITH, CHRISTIANNA, Assistant Professor, Mt. Holyoke College.
SPEIDEL, CARL CASKEY, Associate Professor of Anatomy, University of Virginia.
STARK, MARY B., Professor of Histology and Embryology, N. Y. Homœopathic Medical College.
STOCKARD, CHARLES R., Professor of Anatomy, Cornell University Medical College.
STRONG, OLIVER S., Associate Professor of Neurology, Columbia University.
STURTEVANT, ALFRED H., Member of Staff, Carnegie Institution of Washington.
THOMPSON, IAN MACLAREN, Lecturer in Anatomy, McGill University.
WATSON, ISABELLE, Research Assistant, Carnegie Institution.

WIEMAN, HARRY LEWIS, Professor of Zoölogy, University of Cincinnati.
WILLIER, BENJAMIN H., Assistant Professor of Zoölogy, University of Chicago.
WILSON, EDMUND B., Professor of Zoölogy, Columbia University.
WOOD, FRANK ELMER, Head of the Department of Biology, Illinois Wesleyan University.
WOODRUFF, LORANDE L., Professor of Protozoölogy, Yale University.
YOUNG, DONNELL B., Assistant Professor of Biology, Carleton College.

ZOOLOGY—Beginning Investigators.

ADOLPH, PAUL E., University of Pennsylvania.
ANSON, MORTIMER L., Cambridge University.
BECKER, ELERY R., Instructor, Princeton University.
BEERMAN, HERMAN, Washington University.
BEERS, CHARLES DALE, Student, Johns Hopkins University.
BEERS, CATHERINE V., Assistant Professor of Biology, University of Southern California.
BLAKE, CHARLES HENRY, Student, Massachusetts Institute of Technology.
BOWEN, EDITH S., Instructor in Zoölogy, Wellesley College.
BROWN, ALICE L., Student and Assistant, Cornell University Medical College.
COLE, KENNETH, Instructor, Oberlin College.
COOK, DANIEL, University of Cincinnati.
COWPERTHWAITE, MARION, Instructor, Mt. Holyoke College.
DEFOREST, DAVID M., Union College.
FABER, ERWIN F., Instructor in Anatomical Drawing, University of Pennsylvania.
FOSTER, KENDALL W., Austin Teaching Fellow in Zoölogy, Harvard University.
FRY, HENRY J., Instructor, Department of Biology, New York University Washington Square College.
GRAND, CONSTANTINE G., Research, Cornell Medical College.
GRAVE, THOMAS B., Johns Hopkins University.
HARNLY, MORRIS H., Student, Columbia University.
HARTWELL, RHODA A., Assistant, Illinois University.
HELWIG, EDWIN R., Student, University of Pennsylvania.
HERDMAN, EMMA C., Milet Road, Liverpool, England.
HOPKINS, AUBREY E., Graduate Student, Harvard University.
HOY, WILLIAM E., JR., Professor of Biology, Presbyterian College of South Carolina.
KIERNAN, GRACE R., Instructor of Biology, Miami University.
KNAPKE, BEDE, Teacher, St. Bernard College.
LEWIS, RUTH W., Investigator, Harvard University.
LUCAS, ALFRED M., Wilton, Connecticut.
MACDOUGALL, MARY S., Head of the Biological Department, Agnes Scott College.
MOSES, MILDRED S., Research Assistant, Carnegie Institution of Washington.
PENNYPACKER, MIRIAM I., University of Pennsylvania.
PLUNKETT, CHARLES R., Columbia University.
RATCLIFFE, FRANCIS N., Student, Oxford University.
RICE, KENNETH S., Assistant Professor of Biology, Clark University.
SANDISON, JAMES C., Assistant in Anatomy, University of Georgia.
SCOTT, MIRIAM J., Student, University of Pennsylvania.
STEWART, DOROTHY R., Bryn Mawr College.
STRAUSS, MAURICE B., Amherst College.
STURTEVANT, PHOEBE R., Carnegie Institution.

TILDEN, EVELYN B., Technician, Rockefeller Institute.
THILLAYAMPALAM, E. M., Graduate Student, Columbia University.
VALENTINE, J. MANSON, Assistant, Yale University.
VARIAN, BASIL B., Assistant, University of Pennsylvania.
VICARI, EMILIA M., Research Scholar, Columbia University.
VISSCHER, MAURICE B., Assistant, University of Minnesota.
WALLACE, EDITH M., Carnegie Institution.
WILLIS, JOSEPHINE, University of Pennsylvania.

PHYSIOLOGY—Independent Investigators.

ADOLPH, EDWARD F., Instructor in General Physiology, University of Pittsburgh.
AMBERSON, WILLIAM R., Assistant Professor, University of Pennsylvania.
BAILEY, PERCIVAL, Director, Laboratory of Surgical Research, Harvard University Medical School.
BAZETT, HENRY C., Professor of Physiology, University of Pennsylvania.
BRADLEY, HAROLD C., Professor of Physiological Chemistry, University of Wisconsin.
BRONFENBRENNER, J. J., Associate Member in Pathology and Bacteriology, Rockefeller Institute.
CHOWN, BRUCE, Assistant Dispensary Physician, Johns Hopkins Hospital.
CLARK, JEFFERSON H., Instructor in Pathology, Medical School, Temple University.
CLOWES, G. H. A., Director of Research, Eli Lilly & Co.
COHN, EDWIN J., Assistant Professor of Physical Chemistry, Harvard University Medical School.
EDWARDS, DAYTON J., Associate Professor, Cornell University Medical College.
GARREY, WALTER E., Professor of Physiology, Tulane University.
HARVEY, EDMUND NEWTON, Professor of Physiology, Princeton University.
HECHT, SELIG, Research Fellow, Harvard University.
HINRICHS, MARIE A., Laboratory Assistant, Nela Research Laboratory.
HOLT, L. EMMETT, JR., Instructor, Johns Hopkins University.
JACOBS, M. H., Professor of General Physiology, University of Pennsylvania.
KNOWLTON, FRANK P., Professor of Physiology, Syracuse University.
LILLIE, RALPH S., Professor of General Physiology, The University of Chicago.
LOEB, LEO, Professor of Pathology, Washington University Medical School.
LYON, E. P., Professor of Physiology, University of Minnesota.
MATHEWS, A. P., Professor of Biochemistry, University of Cincinnati.
POND, SAMUEL E., Instructor in Physiology, Washington University.
QUERIDO, ARIE, Harvard University Medical School.
REDFIELD, A. C., Assistant Professor of Physiology, Harvard University Medical School.
ROBERTSON, WILLIAM E., Professor of Medicine, Medical School, Temple University
SCHWITALLA, ALPHONSE, Associate Professor of Biology, St. Louis University.
SHAPLEY, HARLOW, Director, Harvard Observatory, Cambridge, Mass.
SMITH, HOMER W., Harvard University Medical School.
SPAETH, REYNOLD A., Visiting Professor of Physiology, Rockefeller Foundation.
WARREN, H. C., Professor of Psychology, Princeton University.
WOODWARD, ALVALYN E., Associate Professor, North Carolina College for Women.
WULZEN, ROSALIND, Instructor, University of California.

PHYSIOLOGY—Beginning Investigators.

BAKER, HERBERT N., Johns Hopkins University.
BROWN, D. E. S., University of Michigan.
CATTELL, WARE, Garrison, New York.
EGLOFF, WILLIAM C., University of Chicago.
GENTHER, IDA T., Student, Mount Holyoke College.
GLUSKER, S. DAVID, University of Pennsylvania.
HARTLINE, H. K., Lafayette College.
HURD, A. L., Harvard University Medical School.
KREDEL, FREDERICK E., Graduate Assistant in Zoölogy, University of Pittsburgh.
LANDIS, EUGENE M., Student, University of Pennsylvania.
NADLER, JACOB E., Assistant in Biology, Johns Hopkins University.
PAGE, IRVINE H., Research, Eli Lilly & Co.
STUDEBAKER, MABEL T., Chemist, Eli Lilly & Co., Indianapolis.
THOMAS, GILES W., Research Assistant, Harvard University Medical School.
WALDEN, EDA B., Research Chemist, Eli Lilly & Co.
WALDEN, GEO. B., Research Chemist, Eli Lilly & Co.

BOTANY—Independent Investigators.

ALLEN, CHARLES E., Professor of Botany, University of Wisconsin.
BROOKS, MATILDA M., Hygienic Laboratory, United States Public Health Service, Washington, D. C.
BROOKS, SUMNER C., Hygienic Laboratory, United States Public Health Service, Washington, D. C.
CLELAND, RALPH E., Associate Professor of Biology, Goucher College.
COWDRY, NATHANIEL H., 412 Hawthorn Road, Roland Park, Baltimore, Md.
GATES, REGINALD R., Professor of Botany, University of London, Kings College.
HAZEN, TRACY E., Assistant Professor of Botany, Barnard College, Columbia University.
INMAN, ONDESS L., Professor of Biology, Antioch College.
LEWIS, IVEY F., Professor of Biology, University of Virginia.
SCHRAMM, J. R., Professor of Botany, Cornell University.
STEVENS, NEIL E., Pathologist, Department of Agriculture, Washington, D. C.
STOKEY, ALMA G., Professor of Botany, Mount Holyoke College.
TAYLOR, WILLIAM RANDOLPH, Assistant Professor, University of Pennsylvania.
WANN, FRANK BURKETT, National Research Fellow, Cornell University.

BOTANY—Beginning Investigators.

EMERSON, ROBERT, Harvard University.
FOGG, JOHN MILTON, JR., University of Pennsylvania.
HOF, ANNE, Watertown Arsenal, Watertown, Massachusetts.
HOLDEN, ALAN NORDBY, Harvard University.
KEEFE, ANSELM M., Fellow in Botany, University of Wisconsin.
KEMP, MARGARET, Investigator, Radcliffe College.
WILCOX, MARGUERITE S., Laboratory Assistant, Department of Agriculture, Washington, D. C.

STUDENTS.

1924.

Botany.

BEALL, RUTH, Assistant in Biology, Goucher College.
BELL, HUGH PHILIP, Associate Professor of Biology, Dalhousie University.
BETTS, EDWIN M., Student, University of Virginia.
BOUGHTON, ESTHER MARIE, Graduate student, Elmira College.
BUNTEN, EVA ISABEL, George Washington University.
CANBY, MARGARET LESLIE, Student, Pomona College.
DEGENER, OTTO, Amherst, Mass.
FLEXNER, WILLIAM WELCH, Student, Harvard College.
FULLER, ANNIE MAE, Louisiana State University.
HART, HELEN T., Assistant in Botany, Vassar College.
KOCH, NINNA F., Graduate student, Tulane University.
LEVY, CELIA D., Hunter College.
NEAL, MARY EULALIA, Teacher of Science, Boston Schools.
NICHOLSON, JAMES LAWRENCE, Student, Oberlin College.
POOLE, JAMES P., Assistant Professor of Evolution, Dartmouth College.
SABINE, JANET, Student, Radcliffe College.
SCHIMIAN, GERVASE, High School Instructor, St. Vincent College.
STUART, DOROTHY RHETT, Graduate student, Johns Hopkins University.
SHOWERS, EDITH, Smith College.
WALSH, LYDIA BOURNE, Wellesley College.

Embryology.

ALLEN, LOUISE RECTOR, Instructor, Vanderbilt University.
BROWN, ALICE E., 924 Newington Ave., Baltimore, Md.
CHASE, ELTON FLETCHER, Instructor, Tufts College.
CLAPP, EUNICE E., Student, Smith College
CURWEN, ALICE OSBORNE, Student, Smith College.
DILLER, WILLIAM F., JR., Instructor, University of Pennsylvania.
DOWLING, ALEXANDER SCOTT, Student, DePauw University.
FALES, DORIS E., Student, Mount Holyoke College.
GIANG, FREDERICA HSIEN TREN, Student, Vassar College.
LEONARD, DONALD WILLIAM, Wesleyan University.
MEAD, HAROLD TUPPER, Associate Professor Zoölogy, Tulane University.
MEADER, RALPH G., Student Assistant in Zoölogy, Ohio Wesleyan University.
MILLER, RALPH ENGLISH, Assistant Instructor, Dartmouth College.
MULLIN, CATHARINE, Instructor in Zoölogy, State University of Iowa.
ORR, PAUL RUDBERT, University of Pennsylvania.
PARPART, ARTHUR K., Student, Amherst College.
RANKIN, IVA LUCILLE, Assistant Instructor, University of Wisconsin.
ROWLAND, VIRGINIA, Mount Holyoke College.
ROXAS, HILARIO A., Student, University of Chicago.
SANBORN, IRENE HANNAH, Student, Simmons College.
SANDERS, ELIZABETH PERCY, Assistant in Biology, Goucher College.
SCOTT, J. ALLEN, Instructor, University of Vermont.

SLEETER, VICTOR R., Asst. in Embryology Laboratory, Illinois Wesleyan University.
SPENCER, WARREN POPPINO, Ohio State University.
STEIN, KATHRYN F., Mount Holyoke College.
URBANTKE, ELSIE, Instructor in Histology and Embryology, University of Texas, Medical branch.
WENSTRUP, EDWARD JOSEPH, Teacher of Zoölogy, St. Vincent College.
WILLIAMS, ELISABETH, Mount Holyoke College.
WINKLEY, RUTH, University of Michigan.

Physiology.

ATLEE, J. L., JR., Lancaster, Pennsylvania.
CASTLE, EDWARD SEARS, Harvard University.
CLARKE, MIRIAM F., Assistant in Physiological Laboratory, Mount Holyoke College.
GRAY, PHILIP LEWIS, Instructor in Biology, Hamilton College.
HANGER, IRWIN C., Staunton, Virginia.
HAYWOOD, CHARLOTTE, 11 Haewood St., Lynn, Mass.
KENYON, WALTER A., Instructor in Biology, Hamline University.
MERRITT, OLIVE ELEANOR, Instructor in Biology, Hunter College.
MILES, ALICE L., Laboratory assistant, Yale University.
MILLEMANN, RAYMOND JOSEPH, Student, Cornell Medical College.
PEREIRA, JAYME REGALLO, Assistant in Clinical Medicine, Rio de Janeiro, Brasil.
REED, LUCILLE LYMAN, Sophie Newcomb College.
ROOT, WALTER STANTON, Assistant in Biology, Wesleyan University.
TYCHOWSKI, DR. WIKTOR, Zbigniew, Poland, Europe.
WAYMAN, MARGUERITE, Assistant Professor, Hunter College.
WILLIAMS, S. CULVER, Assistant in Biology, Yale University.
WRIGHT, SEWALL, Senior Animal Husbandman, Washington, D. C.
WRIGHT, SYDNEY L., JR., Chemist, Pennsylvania Hospital.

Protozoölogy.

CASS, MILDRED FRANCES, Minor Assistant, Columbia, University.
COLLIER, JANE, Technician, Harvard Medical School.
EICKMANN, REINTRAUT W. M., Graduate Student, Columbia University.
FOGG, LLOYD CLARKE, Graduate Student, Dartmouth College.
GREINER, BRIGHT E., Instructor Zoölogy, Syracuse University.
HOLE, FRANCES L., Instructor, Doane College.
HALSEY, HARVEY RANDOLPH, Laboratory Instructor, Columbia University.
KEITH, WILMA, High School teacher of Biology, 1229 Carr Ave. Memphis, Tenn.
LI, JU CHI, Student, Columbia University.
LITTLE, MALCOLM EDGEWORTH, Laboratory Assistant, Columbia University.
MESSER, HAROLD MADISON, Instructor in Biology, Washington Square College, N. Y. University.
OAKES, MERVIN E., Instructor, Washington Sq. College, N. Y. University.
PHILPOTT, CHARLES H., Professor of Biology, University of Missouri.
PICKWELL, GAYLE B., Instructor in Zoölogy, Northwestern University.
PIRKLE, RUTH JANETTE, Instructor in Biology, Agnes Scott College.
SCHULTZ, JACK, Columbia University.
TAFT, CHARLES H., JR., Assistant Professor, Tufts College.

Attending Morning Lectures Only.

BERTSCH, MARGUERITE, Columbia University.

Zoölogy.

ABRAMS, ELEANOR L., Mount Holyoke College.
ALBRO, HELEN TUCKER, Instructor in Zoölogy, Mount Holyoke College.
APPEL, FRED W., Graduate Student, University of Chicago.
BIRRELL, ETHEL JANE, Science Instructor in State Normal School, Danbury, Conn.
BRADNER, JOHN, Student, Yale University.
BRAY, C. RUSSELL, DePauw University.
BRENNER, NANCY JANE, Hunter College.
BRODE, MALCOLM D., Assistant, University of Chicago.
BRUMMER, FREDA LOUISE, Student, University of Pennsylvania.
CANBY, CAROLINE PRESCOTT, Student, Radcliffe College.
CARR, RALPH WILLIAM, Wesleyan University.
COOLMAN, RAYMOND, Student, Wabash College.
CUMMINGS, ELIZABETH FRANCES, Student, Radcliffe College.
CURRY, LALIAH FLORENCE, Wellesley College.
DOBROSCKY, IRENE DOROTHY, Student, Cornell University.
FORER, ROBERT, Student, Rutgers College.
FOWLER, KATHARINE STEVENS, Bryn Mawr College.
GOLDMAN, DOUGLAS, Student, University of Cincinnati.
HAAS, EDNA L., Connecticut College for Women.
HALL, HARRIS TREMAINE, Student, Princeton University.
HARRIS, DOROTHY LOU, Wilson College.
HAYDEN, CATHERINE SPENCER, Goucher College.
HEYS, FLORENCE M., Assistant in Zoölogy, Washington University.
HUNTER, GEORGE WILLIAM, JR., Illinois University.
JALESKI, CLARENCE THOMAS, Butler College.
KOTTMEIER, MARJORIE, Knox College.
KROPP, BENJAMIN, Graduate Student, Harvard University.
LEICH, CHARLES F., Evansville, Indiana.
LYNCH, JAMES E., Assistant in Anatomy, Washington University.
MACDONELL, THOMAS KENNERLY, Graduate Fellow, Emory University.
MCQUILKIN, WILLIAM EVERETT, Student, Doane College.
MILLER, DAVID K., Illinois Wesleyan University.
NORTHRUP, FLORA E., Graduate Assistant, Washington University.
PARMELEE, ELEANORE W., Graduate Fellow, Mt. Holyoke College.
PIKE, RADCLIFFE BARNES, Bowdoin College.
QUICK, MARY ELAINE, Geo. Washington University.
RAFFEL, DANIEL, Student, Johns Hopkins University.
ROBERTS, JOSEPH MARVIN., Laboratory Assistant in Zoölogy, Illinois Wesleyan University.
RUSSELL, MARY ANNA, Goucher College.
SAYLE, MARY HONORA, Assistant Instructor, University of Wisconsin.
SCHULZE, LULA MAY, Assistant in Zoölogy, University of Missouri.
STEPHENS, MARY ALLEN, Elmira College.
SWAN, DOROTHY M., Colorado College.
SWEETING, MARJORIE A., Barnard College, Columbia University.

TeWinkel, Lois E., Oberlin College.
Tyson, John Joyner, Ayden, North Carolina.
Warren, A. Emerson, Student, and Assistant, Yale University.
Wenner, William Franklin, Assistant Instructor, Yale University.
Williams, Elizabeth T., Smith College.
Zeman, Mira, New York University.

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3. TABULAR VIEW OF ATTENDANCE.

	1920	1921	1922	1923	1924
Investigators—Total	136	172	182	176	194
Independent:					
Zoölogy	69	79	87	90	77
Physiology	22	26	28	23	33
Botany	7	13	15	13	14
Under Instruction:					
Zoölogy	29	34	34	41	47
Physiology	7	11	11	5	16
Botany	2	9	7	4	7
Students—Total	120	120	126	146	134
Zoölogy	56	53	59	59	50
Protozoölogy	15	11	12	16	17
Embryology	26	28	28	31	29
Physiology	15	18	19	22	18
Botany	8	10	8	18	20
Total Attendance	256	292	308	322	328
Institutions Represented—Total	86	95	104	107	110
By investigators	55	67	71	62	69
By students	57	53	68	73	68
Schools and Academies Represented					
By investigators	1	–	–	–	–
By students	7	–	–	4	–

4. SUBSCRIBING AND COÖPERATING INSTITUTIONS, 1924.

Amherst College
Antioch College
Barnard College
Bowdoin College
Bryn Mawr College
Butler College
Carnegie Institution, Cold Spring Harbor
Carnegie Institution of Washington
Clark University
Columbia University
Cornell University
Cornell University Medical College
Dartmouth College
DePauw University
Doane College
Elmira College
George Washington University
Goucher College
Harvard University
Harvard University Medical School
Hunter College
Illinois Wesleyan University
Johns Hopkins University
Knox College
Eli Lilly & Co.
Massachusetts Institute of Technology
McGill University
Miami University
Mount Holyoke College
Nela Research Laboratories
New York University
North Carolina College for Women
Northwestern University
Oberlin College
Ohio Wesleyan University
Presbyterian College of South Carolina
Princeton University
Radcliffe College
Rockefeller Foundation
Rockefeller Institute for Medical Research
Rutgers College
Simmons College
Smith College
Sophie Newcomb College
St. Bernard College
St. Louis University
St. Norbert's College
St. Vincent College
Tufts College
Union College
University of Chicago
University of Cincinnati
University of Illinois
University of Michigan
University of Minnesota
University of Missouri
University of Pennsylvania
University of Pennsylvania Medical School
University of Philippines
University of Virginia
University of Vermont
University of Wisconsin
U. S. Dept. of Agriculture
Vanderbilt University
Vassar College
Washington University
Washington University Medical School
Wellesley College
Wesleyan University
Wilson College
Wistar Institute of Anatomy and Biology.
Yale University

SCHOLARSHIP TABLES

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5. EVENING LECTURES, 1924.

Thursday, July 3,
DR. W. J. CROZIER....."The Nature of a Central Nervous Process."

Friday, July 11,
DR. E. J. COHN....."The Physico-chemical characterization of Proteins."

Tuesday, July 15,
DR. MERKEL H. JACOBS....."Some introcellular changes dependent on differential cell permeability."

Friday, July 18,
DR. L. L. WOODRUFF....."The Physiological Significance of Conjugation and Endomixis."

Tuesday, July 22,
DR. W. B. CANNON....."Some Revelations of the Denervated Heart."

Friday, July 25,
DR. C. R. MOORE....."The Temperature Regulation of the Mammalian Testis and its Relation to Viability in Grafts and Displacements."

Tuesday, July 29,
DR. RALPH S. LILLIE....."Structure and Function in Protoplasmic Systems with Special Reference to the Conditions of Transmission and Recovery."

Friday, August 1,
DR. C. E. ALLEN....."Studies of Inheritance in Sphaerocarpus."

Tuesday, August 5,
DR. J. K. BREITENBECKER....."Genetics of Bruchus."

Tuesday, August 26,

DR. JULIAN HUXLEY....."Bird Courtship and the Problem of Sexual Selection."

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EGG-VOLUME AND FERTILIZATION MEMBRANE.

CHARLES D. SNYDER.

The question of fertilization and egg-volume seems to come up periodically for renewed research and discussion in spite of the papers already written on the topic.[1] In view of the disagreement as to the facts of volume changes at the moment of fertilization the writer wishes to submit the following evidence that was put in a paper in December, 1904, from observations made in that year on two species of echinoderms, and that hitherto has not been published. The work was done at the Timothy Hopkins Sea-side Laboratory of Stanford University, California.

The microscope images of the eggs were projected by a camera lucida, and outline drawings were made of their greatest diameters. Upon each sheet of drawings a stage micrometer scale was also projected and drawn. The magnification was uniform throughout. The diameters given in sections 1–4 inclusive, of this paper, are of these drawings, and should be divided by 110 in each case to get the approximate natural diameter.

1. *Echinarachnius eccentrica.*[2] Eggs made to develop parthenogenetically by treatment with hypertonic salt solution are known to shrink and then to swell again upon return to normal sea-water. Mature eggs of *Echinarachnius eccentrica* put in optimum hypertonic solution for 1½ hours were observed to shrink from a mean normal diameter of 13.27 to a mean diameter of 11.6 mm. After return to normal sea-water for 1 hour the eggs showed diameters ranging from 12.86 to 13.18 mm. By the time cleavage began, and the eggs were still in 1 and 2-cell stages, the diameters ranged between 14 and 16 mm.; when in stages varying from the 4-cell to the morula stage, the diameters ranged between 14.5 and 18 mm. These measurements refer to the egg-cytoplasm, no membranes appearing on eggs so treated.

[1] For review of the literature and discussion of the problem see Lillie, F. R., "Problems of Fertilization," Chicago, 1919, pp. 147–154; also Glaser, Otto: "Fertilization, Cortex and Volume," BIOL. BULL., Vol. XLVII., pp. 274–283, 1924.

[2] Thanks are due to Professor Harold Heath, who kindly identified this species of sand-dollar for the writer.

Of the eggs fertilized with sperm those in 1 to 4-cell stages had diameters of egg-cytoplasm ranging from 13 to 15, and of fertilization membrane from 14.7 to 18 mm.; those in stages from 8-cells to blastulæ had diameters from 14.5 to 16 mm. for egg-cytoplasm, and 16.5 to 17 mm. for fertilization membrane. The number of eggs measured in each case was five only. But the extremes of a large number as well as mean sizes were taken in each case. The mean size of the hypertonic parthenogenetic eggs thus appear to reach nearly the same limit that the membrane does in eggs fertilized with sperm; the egg-cytoplasm of the former apparently takes up water as easily as the membrane of the latter. The writer's observations did not include a large enough number of these eggs at the moment of membrane formation to determine whether or not they showed a preliminary shrinking, as Otto Glaser[1] and others have observed in eggs of other species. One can only say that if the shrinking took place it must have occurred between the moment of the entrance of the spermatozoön and the moment just before the first cleavage.

2. *Asterina miniata* (*Brandt*) *Perrier*.[3]—When mature, and just before fertilization, a sample of seven eggs of this species measured 19, 19, 18.5, 19, 20, 19 and 20 mm., giving a mean of 19.25 mm. and an average of 19.21 mm. in diameter. When treated with suitable amounts of citric acid for a while and then returned to normal sea-water the eggs began to go into cleavage and develop into blastulæ.[4] A fertilization membrane could be seen reaching across the furrows between the cells of these eggs. They differed in this respect from the sand-dollar eggs that were made to go into cleavage by hypertonic solutions. But nevertheless the membranes did not free themselves from the outermost periphery of the egg-cytoplasm. The diameters, therefore, of egg-cytoplasm and fertilization membrane of *Asterina miniata* so treated underwent equal changes; they ranged between 19 and 21, giving a mean diameter of 20 mm. No measurements were made at the moment of treatment with the acid.

[3] Thanks are due to Dr. W. K. Fisher, who kindly identified this species of Asterina for the writer.

[4] The eggs of this species are known to be somewhat naturally parthenogenetic. In the series with the optimum concentration of the citric acid 79 per cent. swimming larvæ appeared at the end of 42 hours whereas in the control only 6 per cent. of the eggs were segmented and none were swimming. The average of all the series worked with showed a natural parthenogenesis to the extent of about 3.5 per cent.

When mature eggs of *Asterina miniata* are treated with sperm, the egg-cytoplasm during early stages of cleavage has an average diameter of 17.7 and the fertilization membrane one of 21 mm. This is shown in the table.

EGGS OF *Asterina Miniata* FERTILIZED WITH NORMAL SPERM.

Stage of Cleavage.	Diam. of Egg Cytoplasm.	Diam. of Fertilization Membrane.	Stage of Cleavage.	Diam. of Egg Cytoplasm.	Diam. of Fertilization Membrane.
1-cell.....	18	20	2-cell.....	18	20
1-cell.....	17	20.5	2-cell.....	18.5	22
1-cell.....	17	20	2-cell.....	18.7	21
1-cell.....	17	21.5	2-cell.....	17.5	22
1-cell.....	18	22.5	2-cell.....	18.5	22
1-cell.....	18	25	2-cell.....	18.7	20.5
4-cell.....	18	21	2-cell.....	19.2	22
2-cell.....	15	20	2-cell.....	19.0	20.5
2-cell.....	15	20	Average....	17.7	21.0

The mean diameters in these observations are 17.1 for the egg-cytoplasm and 22.5 for the membrane. The averages thus show less deviation than do the mean numbers. The amount of shrinking of the egg-cytoplasm comparing the mean diameters before and after fertilization is 11.1 per cent.; comparing the average diameters it is 7.8 per cent.

During the early stage of normal fertilization, then, the eggs of *Asterina miniata* may be said to show a marked shrinking of the egg-cytoplasm.

These figures are of the same order as Glaser (1914) observed for the reduction in diameters of just fertilized *Arbacia* eggs (from 14.4 to 14.5 per cent.) and *Asterias* eggs (from 10 to 17 per cent.); and Okkelberg [5] in volume reduction of eggs of the brook lamprey, 13.4 per cent. Just lately (1924) Glaser [1] repeated the measurements of Arbacia, using an improved method in order to prevent possible flattening of eggs before the membrane has been elevated (first suggested by Reighard, see Okkelberg, *loc. cit.*, p. 97, footnote 2), and finds that the percentage reduction of diameter is less than in his earlier work, but still a demonstrable mean of 3 per cent.

4. In spite of the meagerness of observations (the lack of measurements on the sand-dollar egg during the earliest stages following insemination, the lack of a more perfected treatment to

[5] Okkelberg, "Volumetric Changes in the Egg of the Brook Lamprey . . . after Fertilization," BIOL. BULL., Vol. XXVI., pp. 92–99, 1914.

induce parthenogenesis) the data still furnish one or two points of further interest.

The shrinking of the eggs of *Echinarachnius eccentrica* when subjected to optimum hypertonic solution for parthenogenetic development was from the mean diameter 13.27 before, to one of 11.6 mm. at the end of the treatment, or a reduction of 12.6 per cent. After return to normal sea-water, and by the time cleavage completed the 2-cell stage, the mean diameter was 15 mm.—an increase of 13 per cent.; by the time the eggs were in stages ranging from 4-cell to morulæ the mean diameter was 16.2 mm. showing a total increase of 22 per cent.

In the case of the inseminated eggs of this species the fertilization membrane (assuming it to be present on the unfertilized egg) showed an increase, while developing to the 4-cell stage, from a mean of 13.27 to one of 16.3 mm.—an increase of 22.8 per cent.; eggs in stages of 8-cells to blastulæ showed an increase to a mean diameter of 16.75 mm. or a mean total increase of 26.2 per cent.

In the case of *Asterina miniata* the increase in the average total diameter of fertilization membrane of inseminated eggs is from 19.21 to 21.0 scale divisions or one of 9.3 per cent, comparing averages the increase is 16.8 per cent.; of the acid treated parthenogenetic eggs the increase of both egg-cytoplasm and fertilization membrane (as in the case of hypertonic parthenogenetic eggs of the sand-dollar) is equal, and is the difference between 19.25 and 20.0 mm., or an increase of 3.9 per cent.

5. It may be of further interest to calculate the approximate mean actual diameters and actual volumes [6] of these eggs. If we assume them to have been spheres in all cases we have the following: The mature unfertilized egg of *Echinarachnius eccentrica* has a mean diameter of 120 μ, from which its volume must be about .0009 mm.^{3}; the optimum hypertonic shrinking gave a diameter of 105 μ, or a volume of .00061 mm.^{3}, representing a volume reduction of 33 per cent.

The mean actual diameter of mature *Asterina miniata* eggs is 174.6 μ, representing a volume of .00278 mm.^{3}; the mean diameter of egg-cytoplasm just after fertilization is about 161 μ,

[6] These volumes are calculated by multiplying the cube of the radius by 4.18 in each case. The radius is found by dividing the mean projected greatest diameter of the egg (that given in the text) by 2 x 110, 110 being the magnification.

from which the volume must be about .00217 mm.^{3}, representing a volume reduction of 21.9 per cent. The fertilization membrane on the other hand presented a diameter of 191 μ and therefore enclosed a volume of .00364 mm.^{3}; this represents an increase of volume capacity of 30.8 per cent.

The above observations are summed up in the following syllabus for the purpose of ready comparison. It will be observed that the ratio of diameter and volume changes is roughly as 1 : 2.8, a purely geometrical ratio.

SUMMARY.

Percentage Dimensional Changes in Two Species of Echinoderm Eggs.

Reduction in egg-cytoplasm:

Of *Echinarachnius eccentrica*

By hypertonic salt action—in diameter, 12.6; in volume, 33.3.

By insemination (not observed).

Of *Asterina miniata*

By citric acid treatment (not observed).

By insemination—in diameter, 7.8; in volume, 22.

Swelling of fertilization membrane:

Of *Echinarachnius eccentrica*

Parthenogenetic (hypertonic salt action) [7]—in diameter, 22.8; in volume, about 62.

Normally inseminated—in diameter 26; in volume, about 70.

Of *Asterina miniata*

Parthenogenetic (citric acid treatment) [4]—in diameter 3.9; in volume, about 11.

Normally inseminated—in diameter 9.3; in volume, 31.

No special technical procedure was resorted to, to make certain that the eggs in these experiments were always spherical. The writer cannot, therefore, be quite certain that the diameters given above are those of perfect spheres and accordingly that the volumes given are the exact volumes of the eggs observed. If,

[7] The membrane is assumed to be present here and coextensive with the egg-cytoplasm.

as has been pointed out by others, the eggs at one time may be disks flattened vertically (Reighard, Chambers [8]) and at another time ellipsoids, or pear-shaped objects, suspended at one end of their long axes, and yet at another time perfect spheres, then there is an unrelated error among the observations that renders them worthless.

In the cases here studied there exists only the possibility of the eggs being flattened vertically during the period before fertilization and then changing into spheres after the fertilization membranes are raised from the egg-cortex. This, however, affects only the reduction observed in the inseminated *Asterina* eggs.

No one will doubt that the observed reduction in size of the sand-dollar eggs during the bath in hypertonic salt represents a real reduction in volume. If the effect of the osmosis is a gelation there may have been a hardening of the egg-cytoplasm, but this hardening of itself could not change the egg-mass from a spheroid to a sphere. If the effect of the osmosis is an increase in surface tension then such a change in form may well take place.

The reduction in diameter of the inseminated *Asterina* eggs during the first stage of cleavage is of the same order of magnitude as was observed in the sand-dollar eggs in their hypertonic bath. While some of this reduction may have been due to reshaping, there also can be no doubt that some of it was due to loss of material on the part of the egg-cytoplasm. This material, as others have maintained, may be colloidal in part, but this observation supports the view that considerable water is given off from the egg together with the colloid.

It is remarkable that the percentage of swelling of the egg treated to the hypertonic salt bath, after return to normal sea-water, and the percentage swelling of the fertilization membrane of the inseminated egg should both be of the same order of magnitude. This swelling in neither case can be due to any considerable extent to a reshaping of egg-substance. However evident it is that the egg-cytoplasm of this parthenogenetic egg has undergone a change in permeability different from the egg-cytoplasm of the normally inseminated egg, it nevertheless appears that the limit to extension in the one case is the same as

it is in the other. For since the beautiful demonstration of Chambers [8] there can be no doubt that the fertilization membrane is a preëxistant structure. One may take the limit in the swelling, therefore, to be the degree of permeability and elasticity of the membranes in both cases.

What has just been said of the eggs subjected to hypertonic solution appears also to be true of the eggs subjected to citric acid. For in this latter case the egg-cytoplasm also swells coextensively with the egg-membrane. It will be remembered that in these eggs the membrane could be seen bridging the furrows between the cells after cleavage, in this respect differing from the hyaline membrane that is observed to dip down and follow the furrow closely.[8] The limit to swelling in the artificially parthenogenetic Asterina egg thus also lies in the egg (fertilization) membrane. Only, the citric acid treatment seems to render the membrane somewhat less permeable to water or less elastic, or both less permeable and less elastic, than does the treatment with normal sperm.

In conclusion it may be added that while the above observations contribute little or nothing of a decisive character to the problem, they nevertheless do add to the attractiveness of the space-time method. With the newer technique a thoroughly systematic application ought to yield results not only decisive but also important.

THE JOHNS HOPKINS UNIVERSITY,
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[8] Chambers, BIOL. BULL., Vol. XLI., pp. 318–350, 1921.

THE EFFECTS OF DISLOCATION OF THE EYE UPON THE ORIENTATION AND EQUILIBRIUM OF THE GOLDFISH (*CARASSIUS AURATUS*).

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It has long been known that the eyeballs of various fishes show different movements during locomotion. It is also established that the body movements have an influence on the movements of the eyes.

Lyon [1] has shown that the dogfish compensates rotation about a dorsoventral axis by moving its eyes in the opposite direction. "The eyes," states Lyon, "sometimes show the same motions when the animal moves voluntarily and normally." "A dogfish, for example, when swimming on its side may keep the upper eye to the ventral, the lower one to the dorsal side of the orbit. Compensatory motions are not, therefore, confined to passive rotation by external means."

Lyon found that these compensatory motions of the eyeballs in fish are practically independent of the sense of light, for they cannot be abolished by blinding (transection of the optic nerves). He also found a causal relationship between the semicircular canals and these eye motions.

The opposite question, whether the eye or visual impressions can influence the body orientation and movements in fish has also been investigated but only in reference to the positive and negative heliotropism. Parker [2] has shown that in an unilluminated field dogfish will swim toward a single light, *i.e.*, they are positively phototropic. Thus the light has a stimulating effect on the progressive movements of the fish and Parker concludes that the retinal image is an important factor in guiding the locomotion of these fishes.

Admitting the fact of positive phototaxis in fishes, there still remains the possibility that in diffused light visual impulses or the fields of vision as a whole may influence the orientation, despite

the fact as stated by Lee [3] that "the blinded fish swims normally in all respects."

Numerous experiments by Loeb, Bethe, Bigelow, Lee, Parker, Maxwell, etc., have shown that the labyrinths are concerned with the equilibrium of the fish. The orientation of fish deprived of their labyrinths is very faulty or erratic.

Comparing the striking effects on orientation of labyrinth extirpation with the absence of effects from blinding appears to indicate that the retinal image is not an important factor in equilibrium and orientation in diffused light.

The usual method of studying the influence of the eye on orientation has been that of removal. The difference in the animal's behavior before and after blinding has been interpreted as being due to the removal of the visual function and therefore it is to be considered as representing the normal effect of vision upon orientation and locomotion.

We attempted to approach the problem from a different angle. We tried to investigate the rôle of vision in orientation not by removal but by *dislocation* of the eye, hoping that while the dislocated eye would still perform its visual function, the animal's equilibrium and orientation could be observed and the problem, whether or not the eyes influence orientation, put to a crucial test.

Experimental.

Large goldfish (*Carassius auratus*), eight and twelve inches in length, were chosen for the work because of their availability and especial suitability.[1]

The skull of the goldfish is high, forming a large intracranial space over the brain which permitted the operative work to be done readily. The method chosen was that of dislocation of *one* eye and removing the other. Dislocation was performed by inserting the eye with its nerve and blood supply intact into an artificial orbit placed higher in the skull. This was accomplished in the following way:

A hole about the size of the eye was drilled in the top of the head at a point in the vertical plane of the eyes just to the left of

[1] We acknowledge with pleasure our thanks to Mr. Parker and Mr. Young of the Lincoln Park Zoölogical Gardens, who kindly supplied us with the fish used in this experiment.

the midsaggital line. In the skull and underlying tissue between the left orbit and the drilled hole a narrow channel was cut (including the orbital wall) and thus a communication between the natural and artificial orbit produced. The eyeball was slid along the prepared channel and into the drilled hole, which then served as an artificial orbit. This dislocation can be done very easily and without any force. Neither the eye muscles, nor the nerves of the dislocated eyeball were cut or obviously injured and even the major part of the conjunctiva bulbi and sclerae can be left intact.

The artificial orbit is able to hold the dislocated eye in place indefinitely. At the replacement the dislocated eye showed some healing in the new orbit.

The experiment was successful on two animals. In the third fish a fungus infection on the dislocated eye caused death five days after the operation. To prevent such infections a daily potassium-permanganate (weak solution) bath of the entire fish is necessary.

Immediately following the operation (the first one performed on May 15, 1924) no abnormalities in the animal's behavior were observed. After keeping them under observation for a few days the other eye was removed (May 20, 1924). We were able thus experimentally to produce real cyclopy. These cyclops in their first week behaved exactly like normal blind fish, they swam and oriented themselves quite as before operation. However, after about the tenth day (in our first protocol: June 1, 1924), the animal was observed to tilt the body somewhat to the left. When at rest it assumed a position with its dorsoventral axis several degrees to the left of the vertical. This position was maintained during swimming.

The tilting of the body toward the side in which the eye was dislocated increased day by day, reaching its maximum in about four weeks (in the case of our first animal: June 27, 1924). This maximum tilting was about 45° and was permanent so long as the eye remained in its new orbit.

The gross anatomy of the dislocated eye was quite normal. The media were clear. We observed also some *oscillatory movements* of the dislocated eyes, when we took the fish out of water.

The vision of the fish with dislocated eyes was tested during the period of the last three weeks of the experiment and found to be very good. If a small rod was slowly moved toward the eye the animal quickly turned aside and avoided it constantly.[1] The animal showed in all respects the behavior of a fish in possession of its visual function it avoided all kinds of obstacles. The fishes did not show the phenomenon which Parker described concerning blind fish, *i.e.*, they remain usually near the bottom and swim about in such a way as to be almost continually in contact with some solid surface, as though relying on its sense of touch for its location.

FIG. 1. Goldfish, with the dislocated eye. The other eye removed.

[1] When the animal was near the surface it avoided the rod before it reached the water.

On the 27th of June the dislocated eye was removed from the artificial orbit and slid again along the channel into the original orbit. This operation is also a very easy procedure and can be done without obvious injury of the eye or of the animal.

The animal, as most Anamnia, recovered very slowly from anesthesia and therefore we began our observations on the following day (June 28). The fish was in the normal position at rest and during locomotion. In the several weeks following, the orientation and locomotion were constantly normal, no tilted positions were observed. The other goldfish showed also two weeks after the operation the above described tilting and the tilting reached its maximum six weeks after the dislocation. The results obtained in our second experiment corroborate completely the observations on our first fish with dislocated eye, since in the second animal tilting and the return of vision occurred also synchronously.

At no time during the experiment did the animal show any abnormalities other than the tilting. There were never any evidences of circus movements, etc., which may follow injuries of the midbrain, medulla and labyrinth (Steiner,[4] Loeb,[5] Bethe,[6] Bigelow,[7]).

Discussion.

"A normal fish has a delicate sense of the distance involved in swimming in a straight line. This is shown by the remarkable skill with which he avoids obstacles; in swimming around his aquarium constantly, he strikes his nose directly against the side of the tank comparatively rarely. This is not so with a fish deprived of all his otoliths or with all his macular nerves severed. Such fish seems to have little idea of the extent of a forward swim. He is often restless and frequently alters the direction of his progression" (Lee,[3]). In his experiments Lee did not include the positive side of the rôle of vision in the orientation and equilibrium of the fish. Lee says, "When left to himself, the blinded fish swims normally in all respects, moving gracefully, easily, and without timidity, and shooting and diving like an uninjured fish."

The first question which confronts us is, of course, the cause and mechanism of the tilting following the eye dislocation. There can be little doubt that the tilting is directly due to the dislocation

of the organ for light perception. We avoided injury to the brain and otic capsule and the immediate post-operative behavior of the fish proves that there were no lesions of those organs.

Any continuous tilting of the fish is called a "forced position" by Loeb. Loeb discriminates in one of his earliest papers between two different types of forced responses: "forced movements and forced position." "Wir sprechen von Zwangsbewegungen, wenn die Tiere sich kontinuirlich oder sehr häufig in Bahnen bewegen, die von denen eines normalen Thieres unter den gleichen Umständen in einem bestimmten einfachen Sinne abweichen." And on the other hand: "Wir bezeichnen als Zwangslagen die Abweichungen von der normalen Orientierung gegen den Schwerpunkt der Erde."

According to Loeb the forced *positions* are due to geotropism. Moreover, he refers to the fishes as one of the clearest instances of such phenomena. The normal *position* of fishes in swimming or at rest is also, according to Loeb, a geotropic phenomenon. "Versuchen wir es einen solchen Fisch gewaltsam auf den Rücken zu legen, so widerstrebt er und bringt, so bald wir ihn wieder frei lassen, sich wieder in seine gewohnte Orientierung zurück."

Even the position of the eyes are influenced by the gravitation in the fish. "Bringen wir den Kopf eines Fisches gewaltsam in eine andere als die ihm zukommende Orientierung gegen die Schwerkraft der Erde, so gehen die Augen völlig oder theilweise in die alte Orientierung zurück. . . . Das Licht hat mit diesen Erscheinungen nichts zu schaffen, sie treten auch, wie bekannt, im Dunkeln und bei völlig Erblindeten ein." (Loeb [5]). As Loeb points out the orientation of the fish in relation to gravity takes place by means of the otolith apparatus, as first demonstrated by Mach and Breuer. Loeb cut (in *Scyllium canicula*) the right VIIIth nerve. He saw forced circus movements to the side of the lesion, forced tilting toward the side of the lesion, pleurothotonus, and compensatory positions of the eyeball and fins.

Bethe does not deny the static function of the labyrinth, but he states that the geotropism of the Elasmobranches is not essentially changed by the removal of *one* labyrinth. He failed to observe in many animals the forced positions as after-effects of unilateral labyrinth-extirpation, but admits that forced movements and forced positions of the eyeballs and fins can often be

seen in such animals. He says that the unbalanced tonus and innervation of the trunk, eye and fin muscles (Ewald) can explain satisfactorily these forced motions. But he admits that this tonus factor is also influenced by the geotropic function of the labyrinth.

Although different authors describe somewhat differently the after-effects of labyrinth extirpation (this may be due to difference in technique, injury of other cranial organs, etc.), all seem to agree on the point that the *geotropic* function of the labyrinths is responsible for normal orientation and equilibrium.

No other factor has been considered to play an important part in this behavior. Dogfish in which both labyrinths were removed as observed by Maxwell (8), could hardly be seen to differ from that of the normal fish except when greatly excited. They swim quietly around or settle on the bottom in normal position. Maxwell raised the question whether the orientation of labyrinthless fish is due to retinal stimuli, but his experimental results showed to him that visual impulses did not play a rôle in the orientation of his operated fish. When he covered each eye with a large patch of heavy, black, rubber cloth, the animal swam about with good orientation and never came to rest on the bottom in an abnormal position. This goes to show that in nature chronic or permanent tilting of the body of the fish occurs only from unilateral injury of the labyrinths and never from eye injuries. When both labyrinths are removed there remains no mechanism on which gravity can act in the way to induce orientation, according to Loeb.

In our fish the labyrinths were normal and the otoliths should have taken care of the normal position in swimming or at rest. Nevertheless the tilting of the body took place, as described. Evidently the influence of the labyrinth was modified by a new factor of vision. This factor is probably the influence *of the visual field* on the orientation mechanism.

As long as the vision was impaired by the trauma of the operation, no tilting of the body was noticed. The question is, whether this tilting is a phototropic reaction, a "forced" reaction or due to attempts of the animal to keep its usual visual field. Maxwell admits the possibility of such a mechanism, of course in a different type of experiment: "When the dogfish is rotated

around any one of these axes the eyes move as if to retain their original position in space, or to preserve the original visual field."

We think that the tilting is due to so-called "voluntary" motor attempts of the fish to regain or retain the *usual* visual field.

Heliotropic reactions involve different mechanism in fish than in the invertebrates, for Parker has shown that the dogfish, when only one optic nerve is cut, never moves in circles.

Since in the tank, where the fish lived, there were diffused light conditions, there was no single source of light that could act as a phototropic stimulus. Interpretation of the tilting as a *simple* phototropic response seems therefore excluded.

The tilting at 45° was the optimal condition for the animals to *see* the walls of the aquarium and most of the environment with which he can come in contact and our results indicate that the tilting is a quick reaction of the organism as a whole.[1]

Summary.

1. The dislocation of one eye into the top of the head and the removal of the other eye produce a tilting of the whole body with its dorsoventral axis 45° to the side of the vertical. The reposition of the dislocated eye into its original orbit changes the orientation and equilibrium of the fish immediately, it regains its normal position in swimming and at rest.

2. The tilting is probably due to the attempts of the animal to keep its usual visual field.

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[1] If so, then the fish placed in the dark or by cutting its only optic nerve should regain its normal position. We contemplate to investigate this and related problems in further experiments.